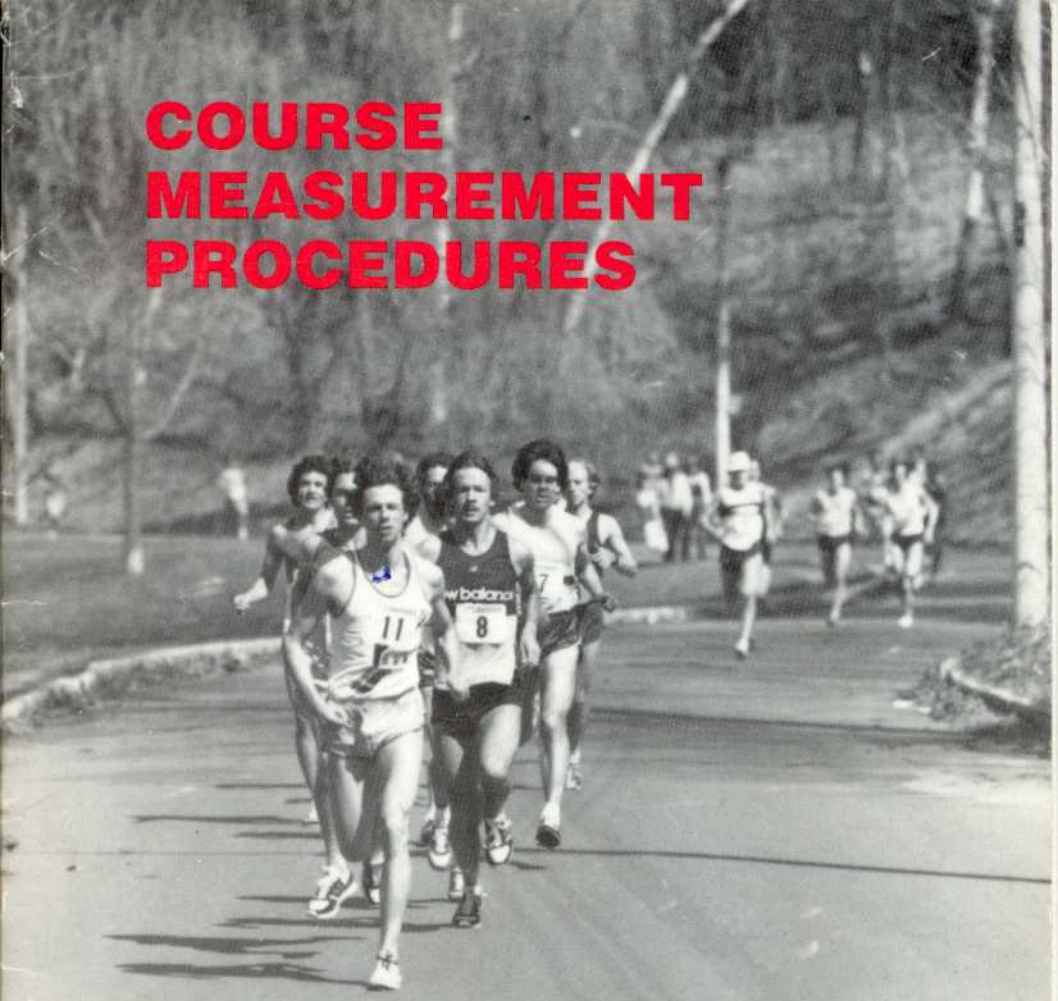
COURSE MEASUREMENT PROCEDURES



Canadian Track and Field Association
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COURSE MEASUREMENT PROCEDURES

The Run Canada Course Measurement Procedures Handbook is prepared by the Run Canada Technical Sub-Committee of the Canadian Track and Field Association.

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We would like to thank TAC Road Running Technical Committee of the USA for the use of the information contained in their second draft Road Course Measurement procedures booklet.

We also recommend the purchase of the TAC Course Measurement Procedures booklet which is very detailed and contains some excellent tips. It is available for $4.00 US from: TAC, 200 South Capital Avenue, Suite 140, Indianapolis, Indiana, USA 46225–(317) 638-9155.

Canadian Track and Field Association
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TABLE OF CONTENTS

SECTION I: A CALIBRATION COURSE

A Calibration Course can be measured accurately in either of two ways:
A) by a team of measurers using a steel tape; or
B) by a land surveyor using an Electronic Measuring Device (EDM)

A. Steel Tape Measurement

1. Measuring Equipment

a) **Steel Tape:** A steel, on a reel, with a minimum length of 30 meters. (A 50 meter steel tape is the easiest to use.) A tape that has been certified is preferable. FIBER TAPES ARE NOT ACCEPTABLE.

b) **Tension Handle:** A tension handle or good fish scale, capable of at least a ten pound tension (4.5 kg) is needed for use with the steel tape to ensure that it is under the proper tension.

c) **Notebook & Pencils:** A small coil notebook (the easiest to use while cycling) and pencils are needed to record data and to make sketches of the course.

d) **Lumber crayons or chalk:** Used for temporary markings on the pavement. As an alternative masking tape may also be used.

e) **Fluorescent paint:** A few cans of fluorescent spray paint are needed for temporary course markings.

f) **Thermometer:** A thermometer is needed to take ground temperature readings so that the steel tape measurements can be corrected for temperature.

g) **Hammer:** A hammer is needed to drive the P-K nails or cement nails into the pavement.

h) **Calculator:** A small pocket calculator is useful in determining the counts needed for specific splits throughout the race course, mile conversions, temperature correction, etc.

i) **P-K nails or cement nails:** Used to mark pavement course markings.

j) **Safety vest and glasses:** A safety vest should be worn at all times throughout the calibration course procedures. Safety glasses or goggles should be worn when hammering in the nails.

2. Personnel

A minimum of three measurers (one leader and two helpers) acts as the recorder, noting the names of the people in the measuring party, their addresses, telephone numbers, the date, temperature on the ground, the wind velocity and direction. For safety it is better to have more than three measurers. The leader should have some experience in measuring with a steel tape.

3. Laying out a Calibration Course

i) Identify a flat, straight, paved road at least one kilometer long. A course of less than one km in length will be accepted ONLY if it is impossible to locate a 1 kilometer course that is flat, straight and paved. UNDER NO CIRCUMSTANCES will a course of less than 0.5 kilometers be accepted. The road should be as close as possible to the start or finish of the race course, and it should have little traffic and few intersections.

We recommend that you use a course of 1 kilometer. We have used a 1 kilometer course throughout this booklet as an example.

ii) Draw a temporary cross on the ground where you will start measuring the calibration course.

iii) Put the tension handle at the 0 end of the tape.

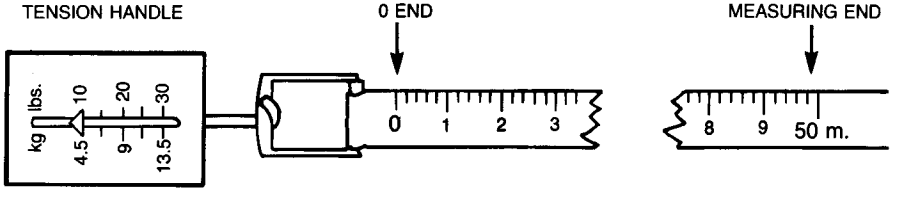
iv) The leader reviews the measuring procedure with all members of the team. He also notes the time the first measurement started.

v) Measure 1,000.00 meters (1 kilometer).

Use 4.5 kg or 10 lbs tension on both 50 meter and 30 meter steel tapes.(9 kg or 20 lbs for 100 meter steel tape) Note: the temperature on the measuring surface (thermometer shaded for 5 minutes). Make sure the tape is flat and straight by shaking it up and down.

Hold the measuring end of the tape (50 m mark) at the cross drawn on the ground and indicate the other end (0 end) with an arrow. Indicate and circle each measuring increment on the ground. Make sure you calculate the correct number of increments. Note each increment in the notebook (20 for a 50 meter steel tape). Lift the tape between markings to protect it from wear and tear.

NOTE: It is useful, as reference points for the cyclists, to paint a dot every 50 meters or so.



vi) At the end of the kilometer, put your safety glasses on and put a nail in the measuring surface. Put the nail so it is accessible to the bicycle wheel. Measure at a distance from the curb so the cyclists can ride where the kilometer was measured. Paint a circle around the nail. Measure from the nail to curb, and at least two (preferably three) acceptable landmarks (such as manhole covers, fire hydrants, lamppost, corner of building) and take note with a good drawing.

vii) Start again and measure the distance between the P-K nail and the starting cross, regardless of whether it measures an exact 1 kilometer or not. Note the measurement. Draw new lines on the ground and identify each new increment. Check the count of the increments and measure according to iv, v, and vi above.

Do a third measurement starting from the first cross you drew to the P-K nail. Do a fourth measurement starting from the P-K nail to the same first cross.

When finished you will have four independent measurements between the same two points.

Note the temperature and time at the begining and end of each measurement.

viii) Calculate and adjust the measurements according to the certified length of the steel tape (if the tape is not already certified).

ix) Calculate the average temperature for each measurement. Calculate the adjustment for each measurement according to the international metal expansion formula (to be used with most steel tapes): $Ct = (t - t_o)$ LK as shown in the example that follows.

x) Now determine the adjusted or actual length of each measurement. The difference between the longest and shortest adjusted measurement must be less than 10 centimeters. If the difference is greater, do another measurement. There must be four measurements within the 10 centimeter limit before it is to be considered as a possible calibration course. Take note of all measurements done and of the results if more than four were needed.

Take the average of the four acceptable measurements to represent the distance between the cross and the P-K nail. Now add or substract whatever distance you need from the cross to come up with an exact kilometer (1,000.00 meter). Put a nail in the road to identify the new cross end of this kilometer (as in vi).

Take note of the north arrow, name of surrounding streets, roads, etc to facilitate locating the standard kilometer, and a legend (if necessary). Complete your sketch so that later you will be able to draw a map similar to the one shown herein as an example in appenix A.

NOTE: For safety reasons, measuring should always be done by adults, 18 years old and over.

4. Temperature Adjustment

When measuring a calibration course with a steel tape, an adjustment for the day's temperature must be performed. If the required adjustments for temperature are not supplied with the steel tape, we can assume that the international steel expansion formula applies to the certified steel tape.

$Ct = (T-T_o)\,LK$

Ct = Adjustment for the length of the steel tape (in meters)

T = Temperature while performing the course measurement (degrees Celcius)

T_o = Calibration temperature of 20°C.

L = Length of the steel tape (in meters)

K = Expansion constant for centigrade temperatures = 0.0000118

All steel tapes are manufactured and calibrated at 20°C. At colder temperatures the tape shortens, and at higher temperatures the tape expands.

Example:

Measurement #1: C t = (13°–20°) 50 m x 0.0000118
= (–7) 50 x 0.0000118
= (–7) .00059
= –.00413 (per length of steel tape) x 20
= –.0826 m
= –8.26 cm

Measurement #1 is actually 999.9174 meters long (8.26 cm short of 1 km)

Measurement #2: Ct = (16.5°–20°) 50 m x 0.0000118
= (–3.5) 50 x 0.0000118
= –.002065 (per length of steel tape) x 20
= –.0413 m
= –4.13 cm

Measurement #2 is actually 999.9587 meters long (4.13 cm short of 1 km)

Measurement #3: Ct = (20.5°–20°) 50 m x 0.0000118
= (+.5) 50 m x 0.0000118
= +.000295 (per length of tape) x 20
= +.0059 m
= +.59 cm

Measurement #3 is actually 1000.0059 meters long (.59 cm longer than 1 km)

Measurement #4: Ct = (23°–20°) 50 m x 0.0000118
= (+3) .00118
= +.00177 (per length of tape) x 20
= +.354 m
= +3.54 cm

Measurement #4 is actually 1000.0354 meters long (3.54 cm longer than 1 km)

Average of the four measurements

The average of the four independant (adjusted) measurements therefore is:

Measurement 1	999.9174
Measurement 2	999.9587
Measurement 3	1000.0059
Measurement 4	1000.0354
	3999.9174

divided by 4 = 999.97935

Therefore the distance between the P-K nail and the cross is actually 999.97935 meters. That means, then, that .0207 meters needs to be added to the course in order to make it an exact 1 kilometer. In other words, the cross should be moved away from the P-K nail by 2.07 cm in order to have a precisely measured 1000 metre course.

B. Electronic Distance Measuring (EDM) Devices

Measurement of the road calibration course by an EDM device is acceptable, as long as the work is performed by a land surveyor and the land surveyor supplies the course certifier with a measuring report and a distance certificate. The report should indicate which EDM device was used, the date the device was last calibrated, the date(s) the measurements were performed, the measurements performed, as well as the usual sketches (see Calibration Course Measuring Report), the adjustments performed to bring the measured distance to the desired distance. (Desired distance is usually 1,000.00 meters.)

C. Filling Out The Measuring Report

The Calibration Course Measuring Report (white form) produced and signed by the course measurement supervisor must contain all the information necessary to explain and demonstrate to the certifiers the manner in which the course was measured.

SECTION II: A ROAD RACE COURSE

Foreword

1) The first step in measuring a road race course is to calibrate a bicycle-mounted Jones Wheel Counter over a calibration course that has been measured with a steel tape or EDM Device. Once the bike has been calibrated, the race course is measured and tentative start, finish and intermediate marks (kilometers and miles) are made. Finally, the bike is re-calibrated, and adjustments are made to the course, establising permanent start, finish and intermediate points.
2) A race course must be measured a minimum of two times in order to receive certification. The course can be measured twice in a row using the same calibrated bicycle, or two measurement can be taken simultaneously using two calibrated bicycles.
3) It is essential that the same cyclist ride the same calibrated bicycle during calibration, when measuring the course, and when checking the calibration–otherwise, the measurements will be distorted, All three operations must be carried out on the same day. It is also important that speed, riding style, and the weigth of the load remain as constant as possible during the three operations.
4) For the safety and protection of the measurer, it is always preferable to have an escort–either police officers or a car with flashing lights following. For safety, always wear a safety vest of a highly visible colour (usually fluorescent orange).
5) Do not take measurements if it is very windy or raining.
6) Jones counters can usually be rented from your National and/or Provincial Track and Field Association. They can also be purchased in at least two ways:
   a) by sending $50.00 in Canadians funds to: The Canadian Track and Field Association 333 River Road Ottawa, Ontario K1L 8H9
   b) by sending $30.00 in US funds to: New York Road Runners Club P.O. Box 881, FDR Station New York, NY I0050 USA Attention Mr. Bill Noel

   These rates are subject to change over time.

A. Road Race Course Measurement Using The Calibrated Bicycle Method

These six steps must be followed in order to make an accurate measurement of a race course:

1) Lay out an accurate calibration course (if one does not already exist in your area). The calibration course must be certified.
2) Calibrate the bicycle (or bicycles) on a calibration course–this step is called pre-calibration.

3) Measure the race course; mark tentative start, finish and intermediate (turn-around) points.
4) Check the calibration–this step is called post-calibration.
5) Make adjustments to the race course following the post-calibration and permanently mark the start, finish and intermediate points.
6) Fill in the measurement report and submit it for analysis. This report consists of a Measurer's Field Report (one for each rider) and a Race Course Measuring Report (filed by the chief measurer).

B. Bicycle Measuring

1. Measuring Equipment

a. **Bicycle Jones Counter:** A bicycle Jones Counter is a measuring device that attaches to the front wheel of the bicycle and counts the revolution of the wheel.
b. **Bicycle:** A "ten-speed" with high pressure tires is best but any bicycle you are comfortable riding is O.K.
c. **A steel tape:** To make possible adjustments to the course.
d. **Notebook & pencils:** to record data and make sketch maps.
e. **Lumber crayons or chalk:** Used to make temporary markings on the pavement.
f. **Fluorescent paint:** A few cans of fluorescent spray paint are needed for temporary course markings.
g. **Hammer:** To drive the P-K nails or cement nails into the pavement.
h. **P-K nails or cement nails:** Used to mark permanent course markings.
i. **Safety vest & glasses:** A safety vest should be worn at all times throughout the course measurement proceedings. Safety glasses or goggles should be worn when hammering in the nails.
j. **Calculator:** A small pocket calculator is useful in determining the counts needed for specific splits throughout the race course, mile conversions, etc.
k. **Compass:** To determine direction when sketching a course map, and when measuring.

2. Notes on Measuring

1) No silk, latex or nobby (all terrain) tires are to be used because of leakage problems.
2) If there are parked cars in the path of your riding route the following procedure is to be followed:
   a) Stop your bike directly behind the impeding parked car(s);
   b) Keeping your front brake clamped (to maintain the same number on your counter) get off your bike and move it horizontally to the outside of the parked car(s);
   c) Get back on your bike, release the brake and ride to the end of the parked car(s); or walk your bike to the end of the parked car(s). Apply the front brakes one again, pick up your bike and move it horizontally back to your ideal "riding line";
   d) Mount your bike again and proceed with course measurement.

3) Install the Jones Counter according to the manufacturer's instructions (appendix A). Ride two or three kilometers to stabilize tire temperature and pressure.
4) Note the general weather conditions, the ground temperature (thermometer shaded for five minutes), condition of the pavement, names of the cyclists, and the date. Make sure that the bicycle's tires are inflated to the correct pressure, and do nothing to change their pressure while measuring the course. Be sure to maintain a consistent body position while riding during calibration, measurement and re-calibration.
5) At the start of the calibration course, place the axle of the bicycle's front wheel above the mark, and note the reading on the counter and the starting time. Ride to the mark at the end of the calibration course and note the new reading on the counter. You must repeat this process at least four times in order to obtain a constant. Ride in as straight a line as possible and at the same speed you intend to ride when measuring the race course (usually between 10 and 15 km/hour).
6) Calculate the difference between the reading on the counter at the start and the reading on the counter at the end of each of the four calibrations.
7) Find the average of the four calibrations.
8) Each calibration that exceeds or falls short of the average by 2.5 or more counts should be rejected. The calibration course should be ridden again in order to find the one calibration what will replace the one that has been rejected. You will need four good calibrations to calculate an acceptable pre-constant.
9) Next, a short-course prevention factor (SCPF) of 0.1% is added to the average of the four accepted calibrations. In other words, the race course will be lengthened by 0.1% (1/1000th) in order to ensure that it measures at least the distance that has been announced. This factor must be calculated and added to the average of the four calibrations in order to come up with the "working constant".

This "working constant" is good for the measuring day only and is the one that is used to measure the race course.

Example: average of the four calibrations: (also called the pre-constant)	9247 counts/kilometer
x the short-course prevention factor	x 1.001
"working constant" wanted	= 9256

C. Measurement of the Race Course

1 Go to the starting point chosen for the measurement of the course and warm up the bicycle tires by riding two or three kilometers.
2 Before you start calculate a list of "expected counts" where you will stop your bike to mark the road. Calculate each stop by multiplying the "working constant" by each kilometer/mile marker you are trying to find. Add the "start count" to each multiplication for a list of "expected counts". Check your calculations. These calculations should be written into your

measurer's field report. For convenience while riding, it may be a good idea to copy the numbers onto a small sheet of paper and tape it to your handle bar.

3 Record the ground temperature and the time the course measurement is started.

4 It is advisable to take measurements in teams of two or more so that each cyclist will have independant calculations (NOTE: the lead rider marks temporary start, finish and intermediate marks along the route. The second rider measures to the first rider's marks, but does not make seperate marks). In this way it will be possible to detect errors more quickly and double check at the temporary kilometer/mile markers.

Ride the race course following the shortest possible route, (appendix B) while taking into consideration the restrictions given by the race director as to where the runner's path will be controlled. On streets with curbs, ride as close as possible to the curb, but no more than 30 cm away; on streets without curbs ride as close as possible to the edge, but no more than 20 cm from the edge (see map). Do not ride faster than 20 km/hour; speed must be controlled when riding downhill and on bumpy roads. Slow down to measure properly around turns. All unpaved sections of the course must be measured with a steel tape.

REMEMBER: Along the way the lead cyclist (or, if only one bike is being used, the cyclist on the first ride) temporarily identifies each kilometer/mile on the ground with the crayon or chalk, as well as in the notebook. The lead cyclist also identifies the start and finish lines. The second cyclist rides to the marks made by the first rider - DO NOT MAKE INDEPENDANT MARKS. Instead, calculate the difference between the "expected counts" (#2 above) and the actual counts on the second bike.

NOTE: When measuring on an "out and back" course where a turnaround is identified by a specific point, measure to and from that point, and not around it.

D. Checking Calibration

1 Check the calibration of the bicycle as soon as you have finished measuring the race course. Follow steps 3, 4, 5 in the section on bicycle calibration.

2 The "POST-CONSTANT" (the one which has just been obtained) must be compared to the "PRE-CONSTANT" (obtained before measuring the race course). (Neither pre nor post-constants have the 0.1% SCPF added to them.) Average of the pre and post-constant (–) minus the pre-constant (=) equals the correction factor.

Example: PRE-CONSTANT (before measuring)	9,247 counts
POST-CONSTANT (after measuring)	9,242 counts
Total of pre and post-constants	18,489 counts
	(÷) 2
average of pre and post-constants	9,244.5 counts
(−) minus pre-constant	− 9,247
equals (=) correction factor	(=) −2.5 counts/km

NOTE: An adustment must be performed for each of the two measurements of the course. Final marks (start/finish/intermediate) are established by using the measurements from the bike (or ride) which provides for the longest course. For example, the first bike measures a course to be exactly 10,000 m long. The second bike rides to the first bike's marks and finds that, by his or her calculations, the course is only 9,999 m long. By the second bikes measurements, one meter needs to be added to the course to bring it to exactly 10,000 m. Therefore, the second bike's measurements provide for the longer course and those readings are used in the final adjustments. If, on the other hand, the first bike provided for the longest course, then those marks would be used in all final adjustments.

E. Final Adjustments To The Race Course

1 In the example given above, the correction of 2.5 counts/kilometer must be subtracted from each kilometer on a cumulative basis. Hence 2.5 counts would be subtracted from the first kilometer, 12.5 counts subtracted at the 5 km point (2.5 × 5), and 25 counts would be subtracted at the 10 km point.

This can done in either of two ways:

a) **Bicycle Method**
On the same day, same bike, same rider, travel to your provisional markings and make the adjustments by wheeling the bicycle forward or backwards the appropriate number of counts. (Attempt to simulate ride weight by putting pressure on handle bars.)

b) **Steel Tape Method**
This method will convert counts to actual distance in meters and centimeters. (This adjustment need not be made on the same day; however, there is a risk of losing your provisional markings due to weather and traffic conditions.) To adjust the course measurements with a steel tape use the following equations:

$$\frac{1000m}{\text{Average of constants}} \times \text{correction factor}$$

eg $\frac{1000m}{9244.5} \times -2.5$

= .1081724 m/counts x –2.5 corrected counts/km
= .27 m/km
= 27 cm/km

2 After calculating the adjustments to be made to each measurement of the race course, write these adjustments down in the notebook. The difference between the shortest and the longest adjusted measurement must be less than .06 meters (60 cm) per race course kilometer. Therefore, for a 10 km race course, a difference of less than 6 meters would be acceptable (0.06%).

Once a minimum of two acceptable measurements has been obtained the longest of these measurements is used to represent the advertised distance of the road race.

3 Permanently identify start and finish lines, depending on your direction of measurement. Take reference measurements in the notebook. Calculate in counts and in meters the adjustments to be made to each intermediate point and/or kilometer of the race course of the chosen measurement. If the course is measured from finish to start, as in the example given above, 25 counts would be added to the start of the course, 22.5 counts to the first kilometer (or the 9th kilometer measured) and 2.5 counts to the first kilometer measured (or the 9th kilometer of the course), and no adjustment would be made to the finish of the course.

NOTE: These necessary adjustments clearly illustrate why only "temporary" marks are made on the ground at the locations determined for the kilometer markers when initial measurements of the course are being taken.

4 Make the necessary adjustments to each kilometer/mile marker. Take reference measurements by using permanent markers for the intermediate kilometers/mile (at least every five kilometers) and record them. Give a precise description in the notebook of all the kilometer/mile markers. As you ride on the course, take time to sketch the line representing the measured path including restricted areas and surrounding detail.

F. The Course Map

A course map showing the ideal line of running as measured is an essential part of the report and becomes part of the certificate of accurate distance issued by the Canadian Track and Field Association. This specially designed course map will be used by the certifiers, the race organizer and the runners. For our purposes, the map needs to be drawn on a single sheet of white paper and drawn in black for reproduction purposes.

In drawing your map you might find it helpful to "widen" the streets relative to their length (1 cm wide streets).

A good map would enlarge sections where more detail is needed and shrink sections where less detail is needed; it would also not include unnecessary single cross-streets, but would show important landmarks for reference. The map must include a line representing the ACTUAL MEASURED PATH through the course. You may find the use of LETRALINE convenient for tracing that line. The map must also include a blown-up section of the exact location of the START, FINISH, and any TURN-AROUND points. This is done by giving precise tape-measured distances from nearby permanent landmarks.

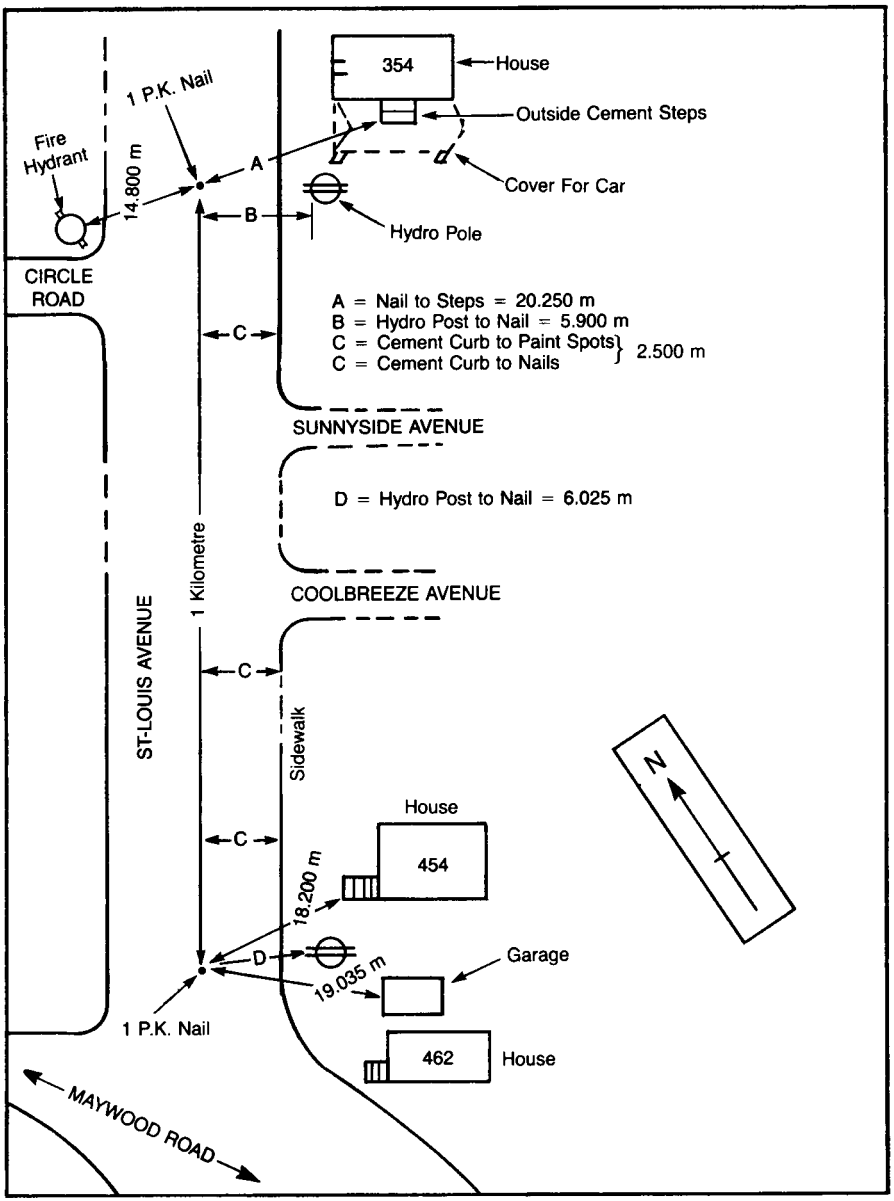
An example of a good course map is located in appendix C

G. Filling Out The Measuring Report

The road race course measuring report (blue form) produced and signed by the head course measurer must contain all the information necessary to explain and demonstrate to the certifiers the manner in which the course was measured and all the information (maps, kilometer/mile splits, sketches, etc) that the race organizer needs to run race using the course AS CERTIFIED. The measurer's field report (yellow form) produced and signed by each course measurer must contain all the field data taken for the race course. Include field notes with this report.

APPENDIX A

Sample Calibration Course Map



APPENDIX B

Installation Instructions For Jones Counter Measuring Device

IMPORTANT: *As you sit on your bicycle, in riding position, device is installed on LEFT SIDE of front wheel, between fork and front wheel.*

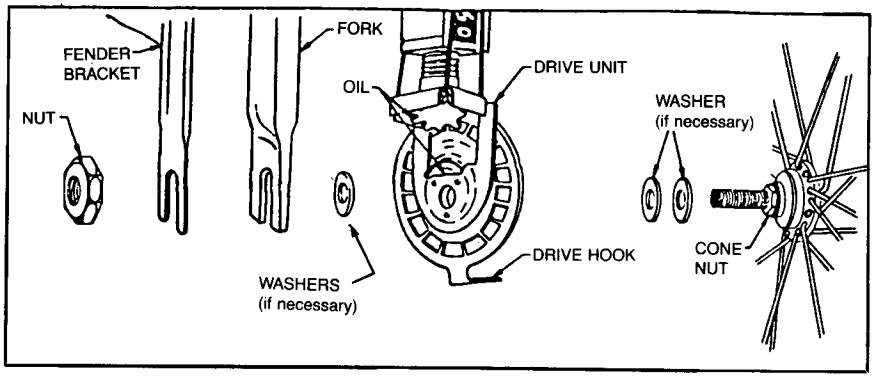


FIGURE 1

Step 1. Turn bicycle upside down and remove front wheel. Use a proper size wrench (not pliers) to remove the wheel nuts.

2. Slide washers onto axle to prevent device from touching spokes when placed on axle.

3. Slide unit onto axle and insert drive hook between any two spokes. If clearance between spokes and drive gear face is greater than 1/32" (width of a penny), remove one washer at a time until 1/32" distance between spokes and drive gear is obtained. See Figures 1 and 2.

Step 4. Insert washer between unit and fork if necessary to give clearance and keep device vertical. Place front wheel with device into fork. It may be necessary to spread the fork slightly to make room for the unit.

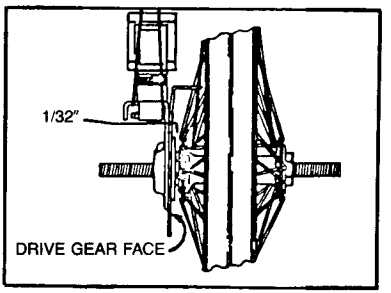


FIGURE 2

Step 5. Replace front wheel nuts removed in Step 1 and tighten.

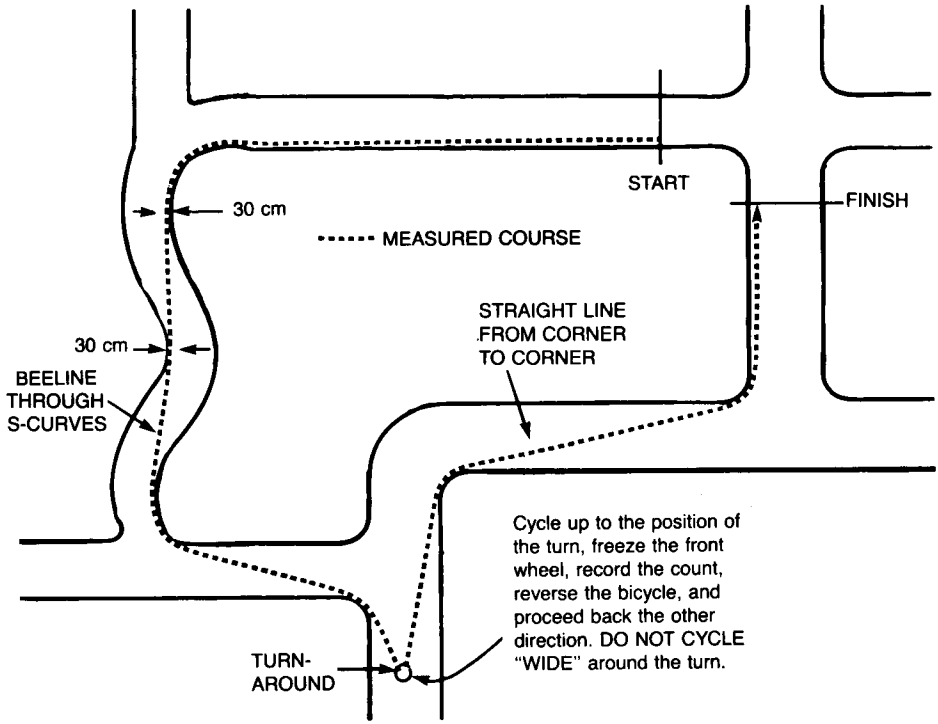
Step 6. Make sure wheel turns freely.

NOTES: Attach counter in such a position that the numbers can be seen while riding.

The counter is not designed for continual use in wet weather. If bike is to be used a great deal for other than measuring, it is recommended that the counter be removed and only mounted while

APPENDIX C

Measure The Shortest Possible Route



ADDITIONAL POINTS

The Race Director, or someone delegated to make decisions about the course route and the start and finish points, should be on hand during the course measurement.

Someone who has run the course and who knows the shortest path taken by the runners should guide the course measurer, or should operate the measuring device.

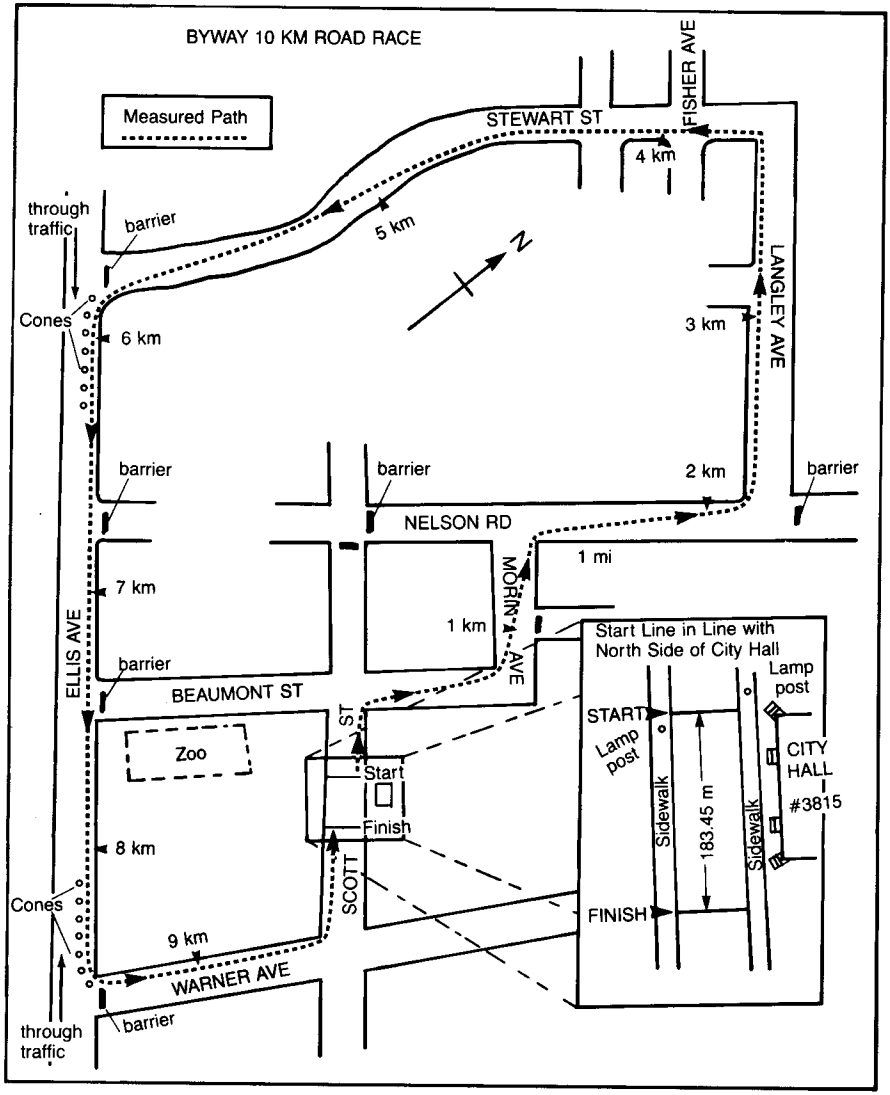
Measure the course when the traffic is light. In dangerous situations, try to get a police escort, or a municipal vehicle with flashing lights on the roof, to be driven along to alert motorists and so protect the course measurers.

Safety of the runners, traffic problems, safety of course measurers, and other practical factors help to determine the course route and configuration.

After measuring a race course, verify the actual running route taken by the runners during the following race(s). Compare the actual route run, with the measured or certified route. In case of discrepancies, measure the actual running route, including all noted short cuts, and get the course re-certified.

APPENDIX D

Sample Course Map



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