

Trial/Pilot Event

Contact the organizers of your tournament to find out what trial/pilot events will be held.

Map It (Division C)

1. **DESCRIPTION:** Participants will use surveying methods and mathematics to map the position of four markers. Measurements will be made from two of the markers (reference points) using simple measuring equipment and/or a homemade surveying instrument. Distances, angles and an area defined by the four markers will be calculated from the collected measurements.

THE COMPETITION:

A TEAM OF UP TO: 2

APPROXIMATE TIME: 40 minutes

2. **The Course:**

- a. Prior to the competition, the judges will set up a survey course of four markers indicating the four points to be mapped. Two markers (A and B) are reference points from which all measurements are made. Participants will not have access to the remote points (C and D) which are positioned so that each forms a triangle with the reference points (ABC and ABD). The length of each side of triangles ABC and ABD will be between 10 and 75 meters. The course may be set up indoors or outdoors on level ground. Near the survey course there will be a room where participants will work on calculations after completing their measurements.
- b. The reference points will be marked with vertical posts no more than 0.5 m tall. The remote points will be marked with vertical markers of any height or vertical fixed objects such as lamp posts, tree trunks, lines on a wall, etc. Each point will be defined as being in the center of its marker. All markers will be visible from the reference points. A circular, one meter radius measuring area will be marked around each reference point.
- c. Prior to the competition, the judges will measure the course to the nearest centimeter (or better). The horizontal distance between the reference points will be provided to the participants at the beginning of the competition. This reference distance will be provided in meter units with four significant figures and two decimal places (25.45 meters, for example).

3. **The Equipment:**

- a. Participants may bring a homemade surveying instrument (plane table, theodolite, rangefinder e.g.) to make measurements.
 - i. The homemade instrument may not be constructed from any item that is commercially manufactured for the purpose of making measurements except for the following: rulers or measuring tapes, magnetic compasses, protractors (the radius of the calibrated arc may not exceed 10 cm), bubble levels, and plumb bobs.
 - ii. No electrical devices may be used, except for non-programmable pocket calculators.
 - iii. Optical devices with curved mirrors or mounted lenses may not be used. Flat mirrors and hand-held lenses are allowed.
 - iv. Instruments must be constructed so they do not touch or obstruct the view of the reference marker when in use.
 - v. Instruments must be constructed so they are fully within the circular measuring area when in use.
- b. Participants may also bring a single page (8.5x11 inches or smaller) of homemade notes (i.e. not commercially printed). No other notes, books, or reference materials are allowed.
- c. Participants must supply any other supplies needed to complete the task (paper, pencils, non-programmable calculators, etc), subject to the same restrictions in items 2a and 2b above.

4. **The Competition:**

- a. At the time of competition the judges will inspect the supplies provided by the participants to assure compliance with the rules above. Supplies do not need to be impounded. Participants will then be given a score sheet indicating the length of the reference line AB and the list of distances, angles, and area to be measured or calculated.
- b. Participants will have ten minutes to make measurements from the two reference points (5 minutes at each point). All supplies must remain in the measuring areas or calculation room while in use. Participants will have access to only one reference point at a time and will not have access to the remote points, or any other part of the survey course. While working in the measuring areas, participants may neither disturb the reference marker nor obstruct the view of the marker from a team that may be working at the other reference point.
- c. After making their measurements, the participants will proceed immediately to the calculation room where they will have an additional 30 minutes to calculate their answers. Score sheets must be turned in before the end of the 30 minute calculation period. Participants may use any method to determine the required answers, including estimation, drawing scale maps, and trigonometric calculations using the laws of sines and cosines.

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d. Participants will be required to calculate three distances, two angles, and one area, reported with the units of meters, degrees and square meters, respectively. The three distances will be chosen by the judges from the unknown distances between the points marked on the survey course (AC, AD, BC, BD, and CD). The two angles will be chosen from all the possible angles defined by three survey points (BAC, ABD, CDA, etc). The area to be measured will be the area of a triangle defined by three points (ABC, ADC, etc) or the quadrilateral ABCD. The measurements selected will be different for each competition and will not be announced until after the participants begin competing. All answers must be rounded off so that they do not have more than four significant figures. For more advanced competitions, judges may use unmarked points (such as the intersection point of lines AB and CD, or the midpoint of line CD) to define a distance, angle, or area.

5. **Scoring:** Prior to the competition, the judges will accurately survey the course in order to determine an accepted value for each of the six measurements. The absolute value of the difference between the accepted measurement and the participants' answer will be used to calculate an accuracy score for each of the six required answers using the formula below. The six accuracy scores will be added to determine the team's final score. Teams will be ranked according to their final score with the HIGHEST score receiving first place. Answers with more than four significant figures will be rounded off to four significant figures by the judges before scoring. Timing is not used in the scoring. If the participants fail to provide an answer for a measurement the accuracy score for that measurement will be zero. In the event of a tie, preference will be given to teams who have the highest accuracy score for the area question.

$$\text{accuracy score} = [1 - (|\text{difference}| / \text{accepted})] \times 100$$

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Sample Score Sheet for *Map It*

(Sample only. The actual measurements will be different for each competition)

Team Number _____ School Name _____

Names of participants: _____
(write legibly!) _____

The distance between the reference points (A to B) is _____ meters.

Distance measurements must be in meters.

Angle measurements must be in degrees.

Area measurement must be in square meters.

Measurement	Your Answer	Accuracy Score
The distance from point A to point C (meters)		
The distance from point B to point D (meters)		
The distance from point C to point D (meters)		
The measure of angle CAB (degrees)		
The measure of angle ADB (degrees)		
The area of triangle ACD (square meters) (tie breaker)		
Final Score = Sum of Accuracy scores = (highest wins)		

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Map It - Coaching Tips

Success in Map It requires that students perform in three areas, building and calibrating a surveying device before the event, effectively using the device during the measurement phase of the competition, and effectively using the data to calculate answers during the calculation phase of the competition. There are several different strategies that may be employed at each step. It will be up to the coaches and students to determine the most effective strategy for solving the problem posed in the rules.

As for building, teams need to choose exactly what it is they want to measure. There are three main options. They could build a device for measuring horizontal angles (a theodolite or transit), a device for measuring distances (rangefinder), or a device for drawing scale maps (plane table). Each device has its advantages and disadvantages.

A simple theodolite could be built with a tube or aligned slits as a sighting device (also known as an alidade) mounted on a rotating platform with an indicator to measure degrees of rotation (such as a protractor). When the device is set up over a reference point (point A for example), you simply align the alidade to point at a remote point (point C) and read the degree scale. Then rotate the alidade to align it with another point (point D) and measure its position on the degree scale. Subtracting the two measurements gives you the angle defined by the three points (CAD) with the reference point A at the vertex. Repeat this process for all other combinations of points to get data for every possible angle. Angles can also be calculated from azimuths measured with a magnetic compass. This option does not require any advance device building.

A simple rangefinder can be built in a similar fashion. In this case you need two alidades mounted as far apart as possible. One is fixed and the other one rotates. Once the fixed sight is aligned with the target, the amount you must rotate the moving sight will be proportional to the distance to the target. A distance scale can be produced by calibrating the device prior to the event with points of known distance.

A third option is to draw a scale map with a plane table. A plane table is perhaps the simplest device to build. All you really need is a flat horizontal surface to write on. Set up any device to sight the direction from a reference point to a remote point, and draw a line in the direction of the remote point. Line up the table at another reference point so the first reference point is lined up with the point on the map and draw a second line in the direction of the remote point. The intersection of the two lines marks the location of the remote point on the scale map. Repeat this process for the other remote point to complete the map.

Having collected data, teams must now calculate the answers. Again there are several options. If you have measured angles with a theodolite, you can calculate all missing angles or distances with the law of sines. If you have distance data measured with a rangefinder, you will also need to use the law of cosines. If you have drawn a scale map with a plane table, you can measure angles directly on the map with a protractor and calculate distances by multiplying the corresponding distance on the map (in mm) by the map's scale factor (length of reference line in meters/length of map reference line in mm). You may also choose to use a combination of methods. For example you could use measured angles or distances to draw a scale map in the calculation room using a protractor, ruler and compass. Finally the area can be calculated can be determined using standard geometry (area of triangle= $1/2 \times \text{base} \times \text{height}$, for example) or even counting graph paper squares on a scale map.

Finally, it should be stressed that these are only some of the possible solutions to the problem. It is likely that there are other strategies that are not covered here. It is our hope that setting hundreds of creative hard working Science Olympiad students loose on this problem will result in a clever, creative, and effective solutions to the problem that we haven't thought of yet.

Here are a few Internet sites that describe some of the equipment and methods described above.

http://www.learner.org/channel/courses/learningmath/measurement/session5/part_a/measuring.html

<http://user.netonecom.net/~swordman/crafts/AmateurSurveying.htm>

<http://uregina.ca/~sauchyn/geog411/mapping.html>

<http://www.themathpage.com/aTrig/trigonometry.htm>

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Sample Survey Course

Measurements are made from the measuring areas marked around the reference points A and B.

The length of the reference line AB will be provided by the judges.

Teams will measure the location of the remote points (C and D) relative to the reference points (A and B). They may measure a distance (such as AC) or an angle (such as CAB).

Teams will use their measurements to calculate the values that can not be measured directly (such as the distance from C to D, the angle ACB, or the area of the triangle ACD). Calculations may involve geometry, trigonometry, or drawing and measuring scale maps.

