Get Excited about the Mathematics & Science in Surveying

Table of Contents

Preface

The following compilation of activities and articles has been kindly prepared by the Mathematics in Surveying Committee, Sydney with the collaboration of the Transit of Venus Committee, Queensland (www.transitofvenus.com.au). Contact details for both organisations can be found on Page 41.

A number of programs have been made freely available for use in conjunction with these exercises such as miniCAD and Stellarium. The sources of these programs are listed on Page 41.

Finally we acknowledge the ongoing efforts of the Profession of Surveying & Spatial Sciences in every state of Australia and the keen interest all Surveyors have shown in demonstrating the following activities in schools and in many cases supplying the instruments and consumables required.

We request that if schools would like a demonstration or assistance in any of the activities, or even a talk on Astronomy in Surveying, that they contact the relevant representative in each state as listed on Page 41.

Introduction

The following series of activities is intended to assist mathematics & science teachers in alternate ways to interest and engage students in the subject of

- Practical hands-on activities;
- Getting students out of the classroom;
- A mathematics & science excursion.

The surveying profession is seeking ways to interest young people in surveying as a profession

- There is a current shortage of surveyors Australian wide;
- Young people know very little about surveying.

What Do Surveyors Do?

Cadastral Surveyors

- Ensure integrity of land title system – who owns that?

Engineering Surveyors

- Key role in the planning and construction of dams, bridges, freeways, high-rise buildings, railways, all new infrastructure projects

Mining Surveyors

- Design mines, tunnels and other underground works

Hydrographic Surveyors

- Map sea floor, lakes, rivers, ports, shorelines, sandbanks
- Locate currents, ensure shipping channels are free from obstructions

Geodetic Surveyors

- Uses satellites to measure Earth's surface accurately, monitor sea level changes, continental drift, help predict earthquakes

Geographic Information Systems

- Production of topographical maps, in-car navigation systems, Google

Photogrammetry

- Extracts spatial information from photographs and digital imaging systems
- Produce maps from aerial photographs, medical image analysis
- Dam and mine surveys, structural analysis of bridges

Also

- Land information management, Remote sensing
- Monitoring effects of climate change, forensics, archaeology

Surveying involves..

- Varied work, both outdoors and indoors
- Using the latest in modern technology
- A choice of working independently or being part of a larger group

Surveying requires..

- Good spatial skills, ability to think and visualise in 3 dimensions
- Attention to accuracy and detail

Due to the current shortage, surveying presents good career opportunities for students with ability in Mathematics and an understanding of physical sciences.

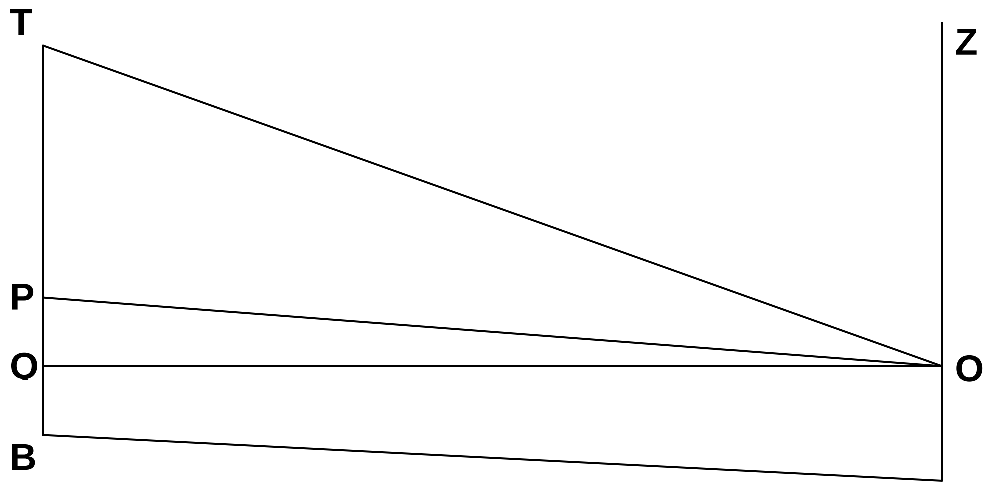
For more information, refer to References on Page 41.

Activity A: Height of a tower, flagpole, building, tree or goalpost

Equipment required: **Total station (jigger), prism, tape to measure height of prism**
Assumed knowledge: **Trigonometry in right-angled triangles – sin, cos and tan**
Duration: **30 minutes or less**

Task: **Find the height of the top of the tower, flagpole, building, tree or goalpost above the base level (that is, the height TB in the diagram)**.

Note: It is not necessary for the ground around the object to be level.
Stand the prism at the base of the object, as close to it as possible.



Before you make any measurements, test your estimation skill by estimating the height of the object, from top to base.

I estimate the height of the object to be . . . . metres

In the diagram:
- T is the top of the object being measured
- B is the base of the object being measured
- O is the position of the observer's eye (at the jigger).
- Z is a point vertically above O (called the zenith point)
- Q is a point vertically below T on the same horizontal level as O
- P is the prism (may be above or below Q)

Given information: Height of prism above the base of the object: PB = metres

Observations:

Zenith angle of top of tower:	(Angle ZOT)	____________
Zenith angle of prism:	(Angle ZOP)	____________
Slope distance to prism:	OP	____________

Calculations:

Look first at triangle POQ
What is the length of OP? ____________
What is the size of angle POQ? ____________
Use this to work out the length of OQ ____________
Use this to work out the length of PQ ____________

Now look at triangle TOQ
What is the size of angle TOQ? ____________
Use this to work out the length of TQ ____________

Now find the height of the object TB ____________

Activity B: Mapping an area using clock bearings

Clock bearings are measured in the same way as true bearings. Have the student face the reference direction, which is called 12 o'clock, and then point an arm in the direction of the next place to be recorded on their map. The hour this arm makes with 12 o'clock can be estimated and recorded. Encourage students to be as accurate as they like with the clock bearings. Given that they should be able to discriminate the hours easily (eg between 3 and 4 o'clock), they may be able to provide more fine-tuned measurements (for example, 3:15). Given that right angles feature predominantly in building, discussion will hopefully reveal that most of the subsequent clock-bearings differ from each other by 3 hours.

Note that you can choose any convenient clearly-marked direction as the reference direction, for example, a boundary fence or the main facade of a building.

An example of measuring up an area using clock bearings and steps

Step 1: Number the points to be mapped

The features of the area are numbered and students instructed to map them in that order (see the diagram below). Note that in this case the corners of the building have been numbered so that the students will walk in a particular direction around it. A tree has also been included (point 11).

Step 2: Decide on the 12 o'clock reference direction

In this case there was a road adjacent to the building. The perpendicular to the road at any point was chosen as 12 o'clock. Coincidentally, this direction was also along the main axis of the building.

The student standing at point 1 faces the direction of the red arrow, the arbitrary 12 o'clock. With their arm they point down the building towards point 2. The clock bearing from point 1 to point 2 is clearly 12 o'clock.

Step 3: Record the measurements

The bearing of 12 o'clock from point 1 to point 2 is recorded on a table (shown below) and the student then walks to point 2, counting the number of steps (which was 26 steps). The next diagram shows the process being repeated at point 2. They face 12 o'clock, point an arm at point 3 and measure the bearing of 9 o'clock.

They then walk to corner 3 counting and recording the number of steps. From 3 they repeat the process to 4, and so on, recording each bearing and distance until they end back at point 1.

Table recording the measurements

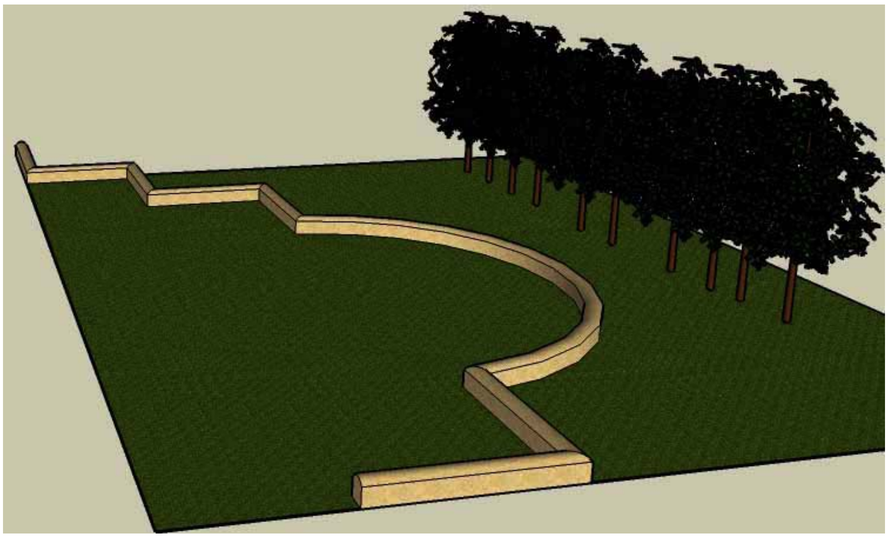
From point…	To point…	Clock-bearing	Number of steps
1	2	12	26
2	3	9	16
3	4	6	11
4	5	8.30	3
5	6	6.30	17
6	7	9.30	2
7	8	6	7
8	9	3	28
9	10	12	12
10	11	1.30	18
11	1	8	20

This data can then be entered directly into a computer to produce a map. For details, see the instructions for using the miniCAD software.

Activity C: Mapping an area using compass bearings

Preparation: Try to choose an area that is not just a simple rectangle, but if that is not possible, a basketball court could be used, perhaps with some extra objects placed on it whose location has to be marked.

Equipment required: Measuring tape, magnetic compasses, grid paper and geometrical instruments, including ruler and compasses.
Assumed knowledge: Taking bearings using a magnetic compass, measurement formulae, scale.
Duration: 30 minutes



A. Measure up the area.

Draw a rough sketch map of the area. Choose any corner as starting point and label it 1, then number the other corners in sequence, as in the example shown. The number of points will depend on the shape you are measuring. Use a tape to measure the length of each side.

Now use a magnetic compass to find the direction of the longest side (remember that compass bearings are measured clockwise). If all the corners are right angles, you should be able to work out the directions of the other sides, using the fact that all the corners are right angles. If not, use the compass to find the direction of the other side's too.

B. Prepare a table of bearings and distances

Enter the results in the table giving the bearing and distance for each leg (e.g. if there are 10 points – 1 to 2, 2 to 3, … 9 to 10, 10 to 1).

From point number	To point number	Bearing	Distance
1	2		
2	3		
3	4		
4	5		
5	6		
6	7		
7	8		
8	9		
9	10		
10	1		

C. Draw a map of the area you have measured

Using your geometry equipment and the data in your table, draw a map of the area on grid paper provided by the surveyor or your teacher. Use a scale of 1 cm to 1 metre, i.e. 1:100. Mark North clearly on your map.

Check with a surveyor that you have done this correctly.

D. Use your map to calculate the area of the region.

Show your working and give your answer (in m^2, to 4 significant figures).

Keep the table carefully. You will need it later, when you enter the data into a computer in Activity D.

Activity D: miniCAD

Location: Classroom with computers
Duration: 30 minutes
Resources: Refer to Page 17 for software download

In this activity, you will learn how to use the Computer Aided Design software package *miniCAD*. You will be shown how to enter into the computer the results from Activity C(Mapping).

Make sure that you have to hand the table of distances and bearings that you made in **Activity C.** You will use this to draw on the computer an accurate map of your measurements of the area, and then find the exact location of the two mines, and get the computer to calculate the area.

CAD stands for Computer Aided Design / Drafting and miniCAD5 is a powerful CAD program designed for surveyors to produce maps from their survey data. Today you will use it to produce the same map as you have just drawn on graph paper. When you have finished you will be able to print it out. If you have any problems, put your hand up and get one of the surveyors to assist you.

The following instructions are written for groups mapping a garden feature or basketball court that includes a circular arc. If the area you have mapped does not have a curved section in its boundary, ignore Steps 5 and 6 and go straight from Step 4 to Step 7..

Step 1 – If it is not already done, open miniCAD5 by double clicking on the desktop icon.

Step 2 – Start a new job by selecting **File>>New** from the menu.

Step 3 – You should see one point in the middle of the screen, labelled with the number 1. If a point number is not displayed, move the mouse cursor into the drawing area, right click and select **Display>>Numbers**

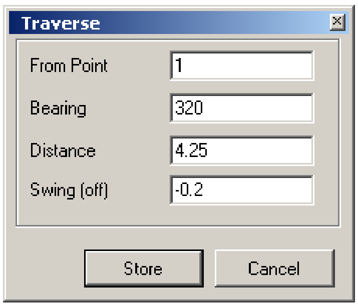
Step 4 – **Select Draw>>Traverse** from the menu. Move the mouse over point 1 and left click when the cursor turns yellow. This is what you do if you are told to "snap to a point".

Next, you will enter the bearings and distances you measured (surveyors call these traverse legs).

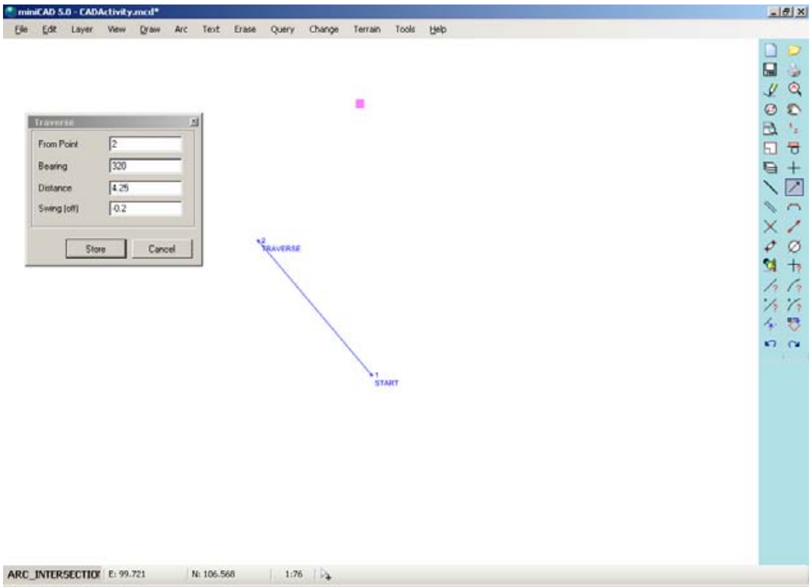
Enter the first bearing and distance from your table.

Ignore the Swing field, unless it is shown in red, when you will need assistance from a surveyor.

Your dialogue box should look like the picture below. Press the **Store** button when finished.



Your screen should now look like the picture below. If it doesn't, see the box below.



If your drawing looks too small or if it disappears off the screen, you can change the scale by Zooming or move it by Panning.
Zooming lets you make the drawing bigger or smaller. **To make it smaller (zoom out)**, roll the wheel of the mouse towards you. **To make it bigger (zoom in)**, roll the wheel away from you.
Panning lets you move the drawing around the screen, without changing the scale. **To pan**, hold the wheel of the mouse down and drag the mouse.

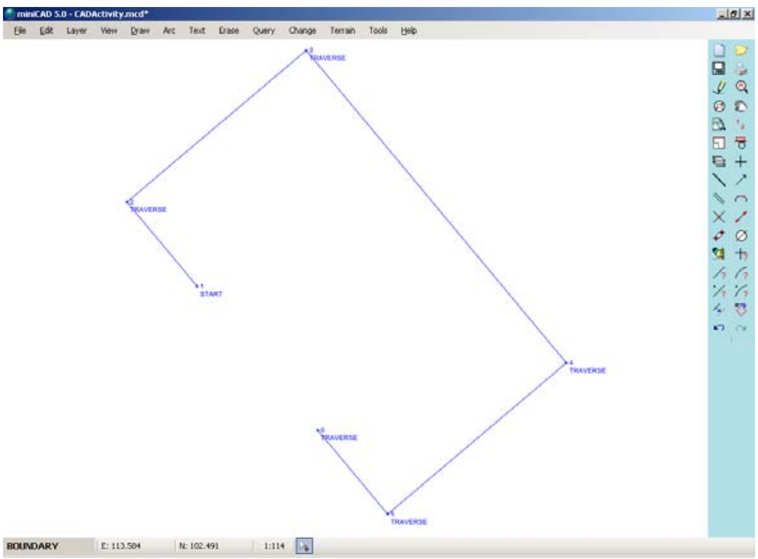
Continue entering all your traverse legs:
If you make a mistake select **Edit>>Undo** and re-enter the traverse leg.
The undo command can be used at any time you have a problem. There is also a Redo command if you undo too far.

If the boundary of the area you are mapping does not contain any circular arcs, when you reach the last point, select **Draw>>Line** and click on the first and last points to complete the map.

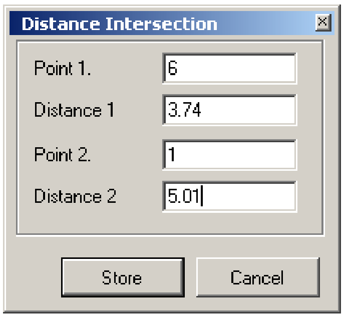
If the boundary does contain a circular arc, stop when you get to the last 2 traverse legs (the legs attached to the point on the arc).
Press the Cancel button on the Traverse dialogue box.

From now on, you should Cancel each dialogue box when you have finished with it, without needing to be reminded.

Your screen should now look something like this

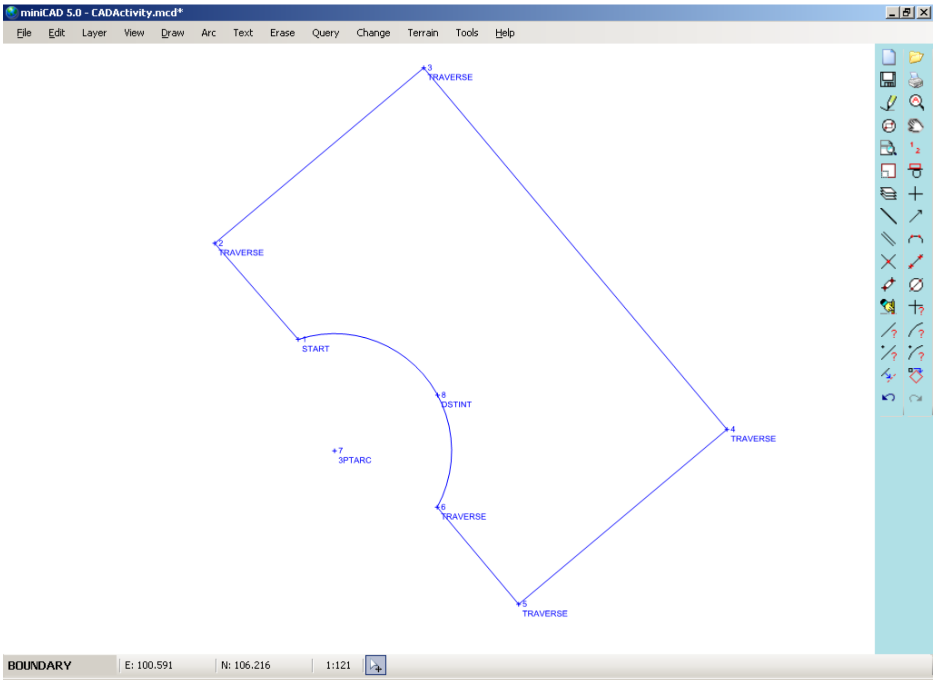


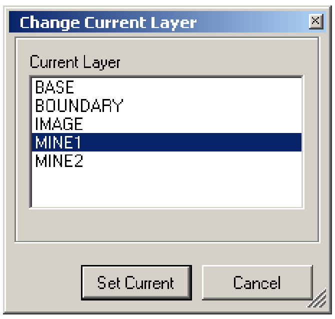
Step 5 – S**elect Arc>>2 Arc Intersection**.
Enter the number of the first endpoint, and the distance measured from it to the point on the arc. Then enter the number of the other endpoint and the distance from it to the point on the arc. This tells miniCAD to perform a 2 arc intersection. Your dialog box should look like the one below.



Press the Store button.
Two points should appear on your screen, because two arcs (circles) intersect in two places. One of the two points should be on the arc location, whilst the other one will be clearly wrong. Left click your mouse on the wrong point, and press the Delete key on your keyboard to remove it.

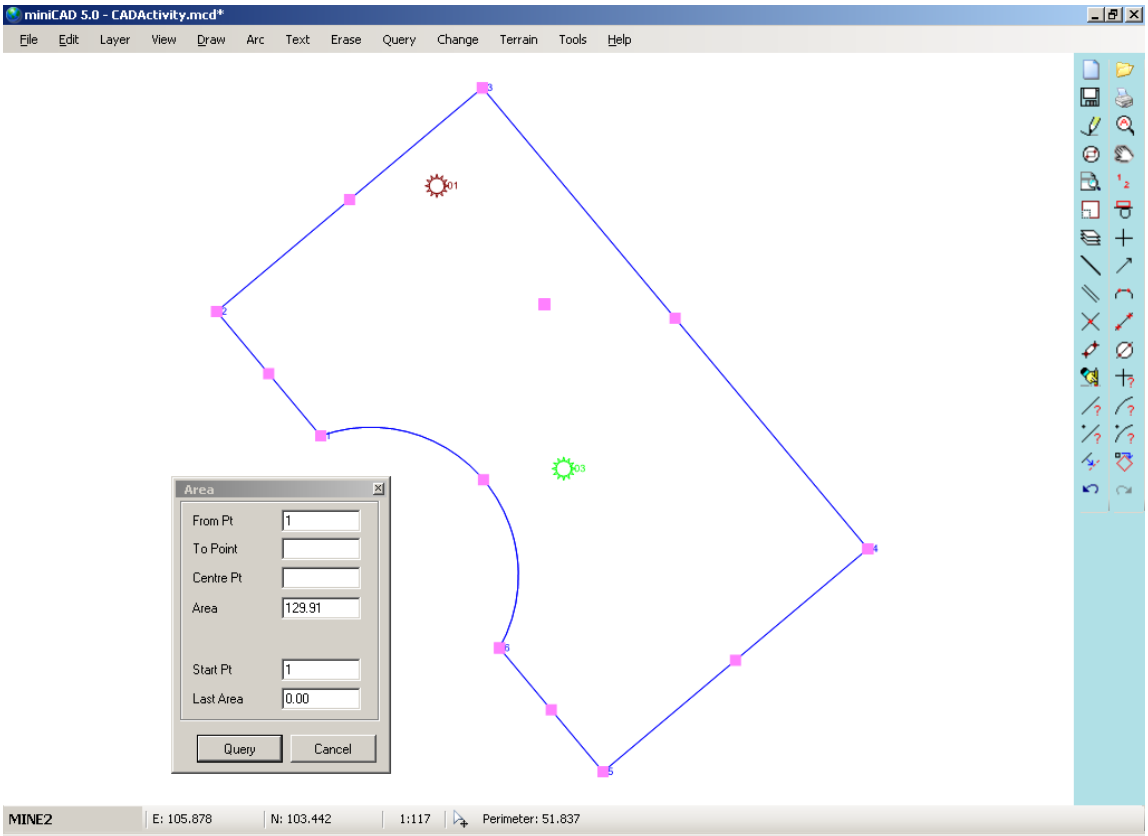
Step 6 – To complete the arc, **select Arc>>3 Pt Arc**.
This command requires you to select the 3 points on the arc in any direction. When you have completed this, press cancel. Your screen should look something like the picture below.





Step 7 – Calculate the area of the lawn using miniCAD

Select Query>>Area from the menu, move your mouse into the centre of the lawn and left click the mouse. The area should be displayed as below.

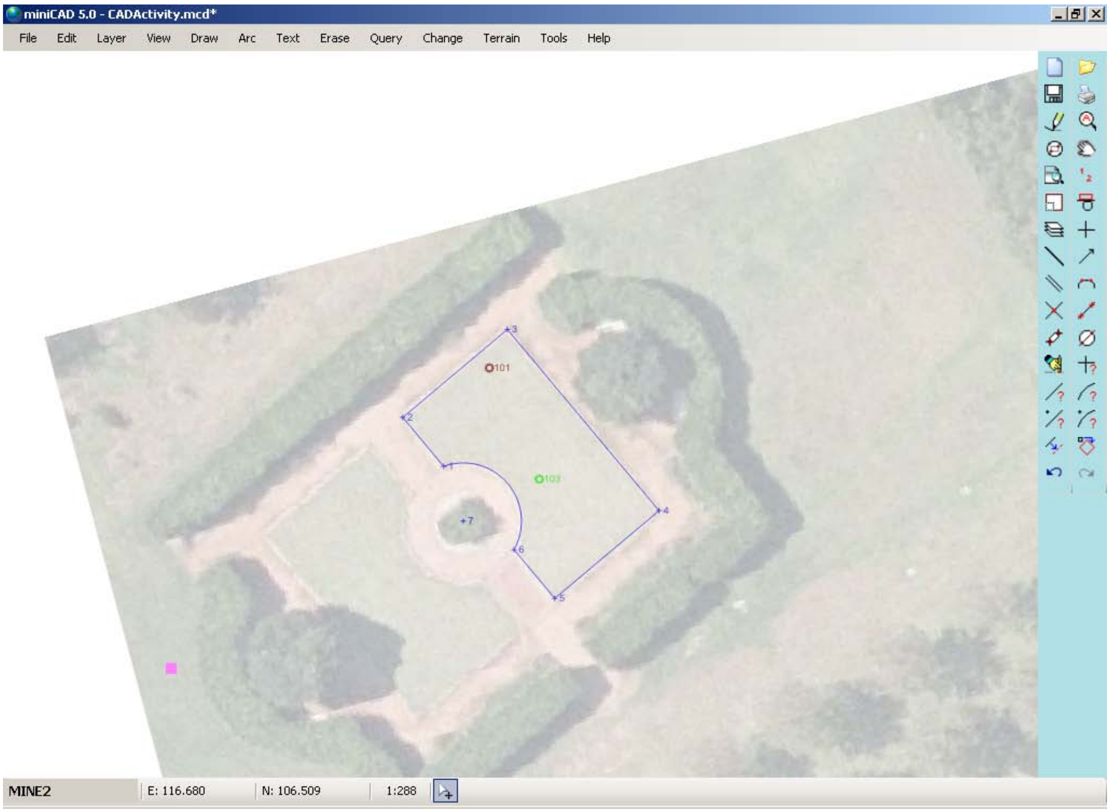


Step 8 – This step is optional. If you have less than 10 minutes available, **skip this step and go on to step 9 to print your map.**

First you need to obtain an **aerial photograph** of the area you have just entered into miniCAD. Open Google Maps on the internet and zoom to the area you have just mapped. Press the **Print Screen** key usually found on the top right of the keyboard. Sometimes the key is labelled PrtSc or PrtScr.

Open Windows *Paint* or another graphics package and paste the image into it. Save it as a TIFF, JPG, BMP, PNG or GIF file. Place this file in the same folder as your miniCAD drawing. You will now geo-reference the photograph. This involves inserting the photograph into your drawing and aligning it with your map. Follow the instructions on the next page.

Select Draw>>Insert Image from the menu.
Use the mouse to define an area on the screen in which you will place the photograph: Left click on one corner of the screen and drag to the diagonally opposite corner. Make the defined area fill the screen roughly over your drawing. Check that the correct image type is set and select the image file you saved.
Right click the mouse and **select Cancel – Image**.
Right click the again and select **Geo Reference Image**.
Instructions will now appear in the message bar on the bottom right of the screen.
Click on 2 points on the photograph followed by the same 2 points already created in your map. Nothing will happen in the main part of the screen until you have clicked on all four points.
You can pan and zoom the screen while you select these points. You should finish with something like the picture below.



Step 9 – Finally you are ready to **print your drawing**.

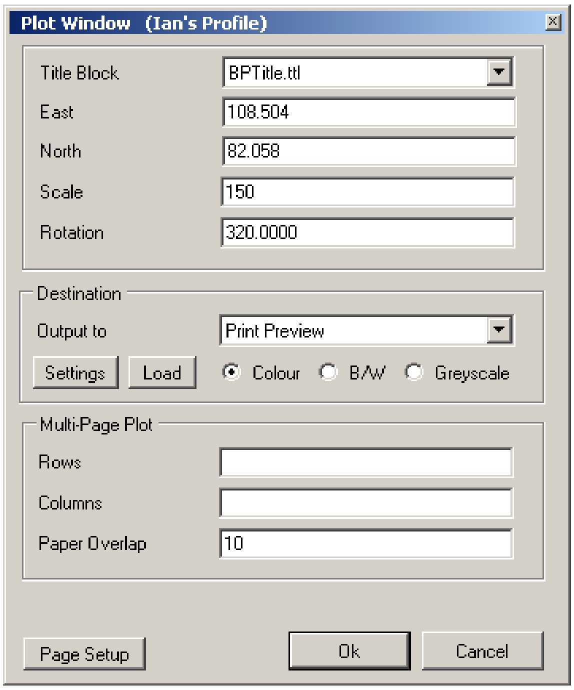
Select File>>Plot Window and enter the following information in the dialogue box that appears:

First **select the Title Block**. (A title block provides a border around your plan and some information about the plan.)
From the drop-down list, select BPTitle.ttl.

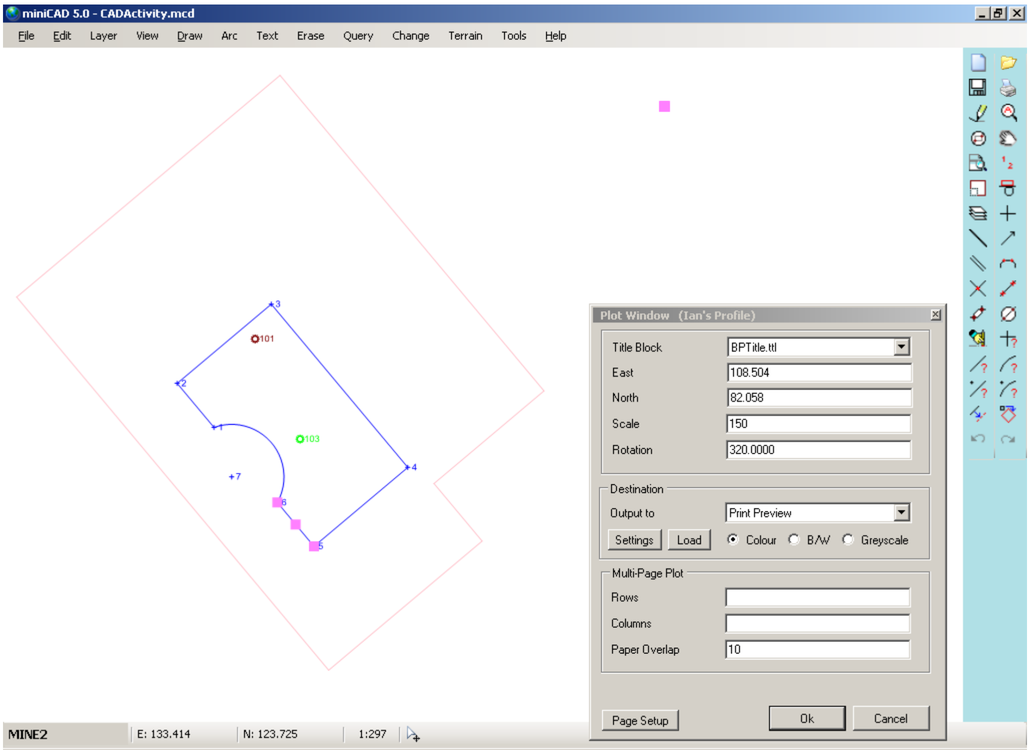
Next **drop down to the Scale field** and enter a scale of 100.
Left click your mouse **where you want the bottom left corner of the title block** to be, and the title block will appear on screen. It looks like the outline of a rectangle, in yellow, with a smaller rectangle cut out of it (where the information will go).
If the title block is too small for your plan, change the scale to 150.

P**ut the cursor in the Rotation field** and click on a line in your drawing.
This will align the title block with that line.
You want to get the whole of your plan to lie within the outline of the title block.
If the title block is not quite in the right position, you can move it by left clicking in the drawing area at the location where you think the bottom left-hand corner should be.
You may need to do this a few times as well, before you get it right.

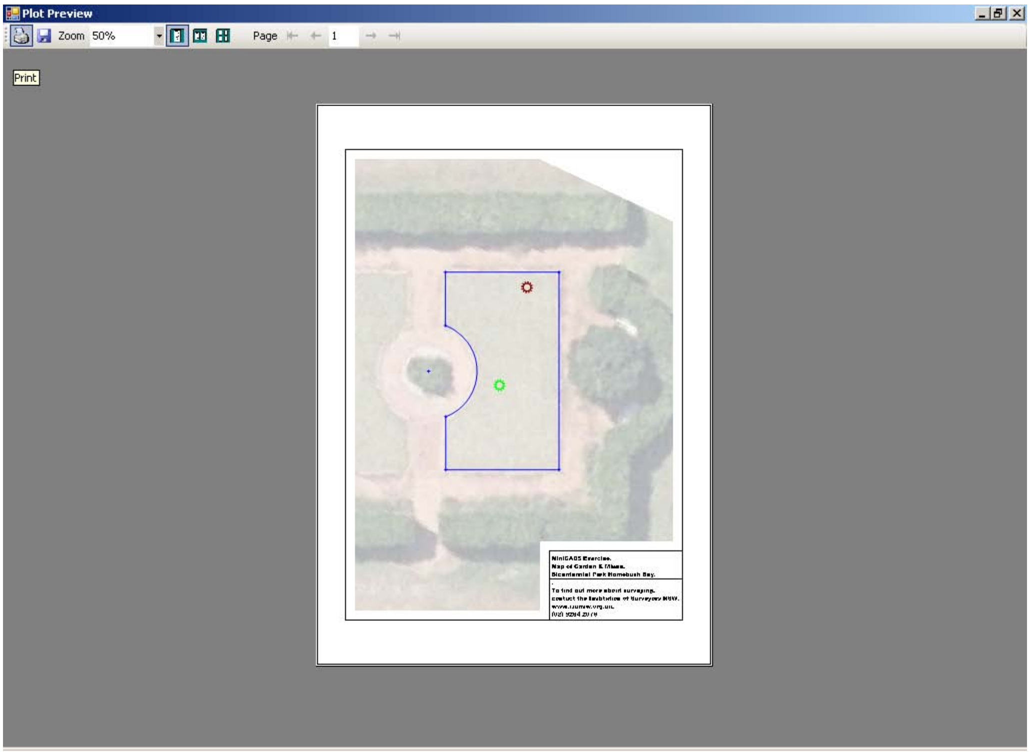
Next select **Output to Print Preview** and **click on the Colour button**.
Ensure the Rows and Columns fields are either blank or have zero in them.
Press the Page Setup button and set it to A4 sheet size and Portrait orientation.



Press OK to return to the Plot Window settings, then **press OK again** to view the print preview. Note in the picture below, the image is turned off to make it easier for you to see the outline of the title block. In your case the image should also appear.



Your plot sheet should look like this:



Press the printer icon in the top left corner of the window above and print your sheet.

Congratulations on completing your miniCAD5 tutorial. Pretty easy isn't it? Press F1 to read the help files and make you an expert in its use.

If you liked using miniCAD5, you can download the program free from www.mapsoft.com.au and install it on your PC at home. Speak to your teacher about installing it in your school computer lab. Additional resources and files are needed for the activity. They can be found at www.mapsoft.com.au/Version_5/help/docs/Tutorial5_Resources.zip .

When you have downloaded and unzipped these, if you are not sure how to use them, see the "ReadMe" file which is included.

Activity E: Marking a path through a Minefield

Assumed knowledge: Compass bearings, measurement, accuracy, intersection of circles.
Duration: **30 – 40 minutes**

Equipment required:

For preparation: If doing the activity on grass, you will need galvanised iron roofing nails and flagging tape to mark out the rectangles. If doing it on a paved surface, mark out the rectangles with chalk.

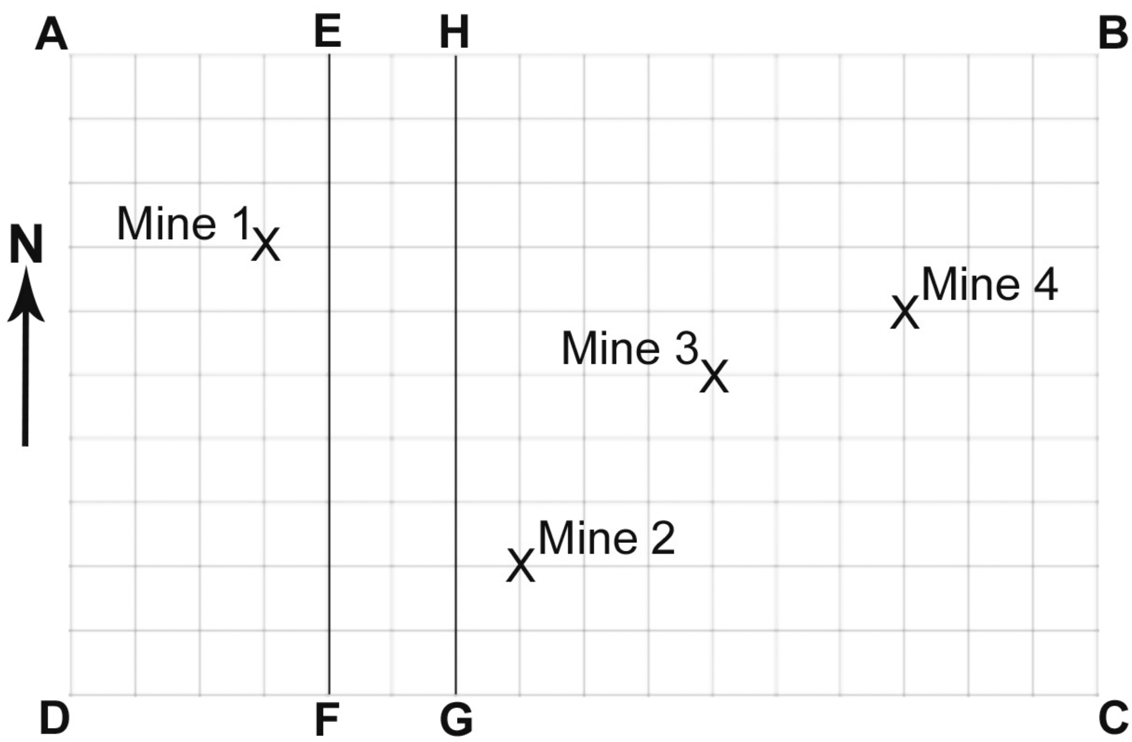
For each group: Copy of the student worksheet, 30 m measuring tape, magnetic compass, ball of string, a few galvanised iron roofing nails, sheet of 1 cm grid paper, and geometry instruments—pencil, ruler, compasses and protractor.

Preparation: In the school grounds or some other suitable area like an oval or a park, mark out a rectangle 16 m by 10 m. Preferably, it should be laid out on grass, using flagging tape with nails to hold the tape in place, but if that is not possible, mark it with chalk on a paved surface. If several groups are to do the activity simultaneously, you will need to mark out a rectangle for each. Each rectangle should be oriented so that its long sides run east-west and its short sides run north-south, as shown in the solution diagram below.

The student worksheet is on the next page.

Solution:

Minefield Map Scale: 1:100



The solution shown is the only path that meets the requirements and is at right angles to the long sides of the rectangle, and therefore the shortest route. Paths that go at an angle across the area are also possible.

Student Worksheet – Marking a Path through a Minefield

Imagine that land mines have been buried underneath the ground inside the marked rectangle. Your task is to use information about the positions of the mines to mark out a safe path, so that you can lead a group of refugees through the minefield to safety. In carrying out this task, take care not to step inside the marked rectangle until you have pinpointed the positions of the mines, otherwise you might be blown up!

1. Draw a scale map of the rectangle ABCD which contains the mines (see Figure 1). It has been marked out on the ground for you. Begin by measuring the sides AB and AD. As a check, also measure sides BC and CD. With a magnetic compass, take a bearing along the long side AB, from A to B. As a check on your accuracy, take a bearing from B to A. The two bearings should differ by 180° ± 5° (the accuracy of your handheld compass). On your grid paper, draw the rectangle using a scale of 1:100 (i.e. 1 cm to 1 metre). Mark the scale on your map, and include an arrow indicating the direction of North.

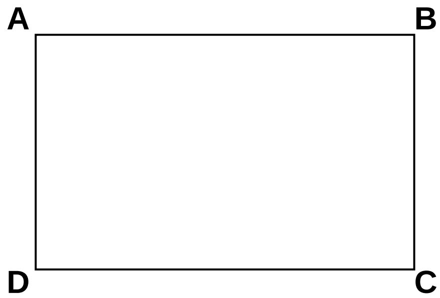


Figure 1

2. Using your geometry tools, draw in the positions of the mines on your map.
Mine 1 is located on a bearing of 135° from A and 257° from B.
Mine 2 is located on a bearing of 140° from A and 74° from D.
Mine 3 is located at 7.8 metres from C and 11.2 metres from D.
Mine 4 is located at 5 metres from B and 6.7 metres from C.

Indicate the position of each mine with an X and a number.

3. Find a safe path from one side of the area to the other and draw it on your map. The path needs to be 2 metres wide and its edges must always be at least 1 metre from the mines, in case vibrations from people's footsteps set off one of the mines. Your result may look something like Figure 2. Mark the sides of the path as EF and GH.

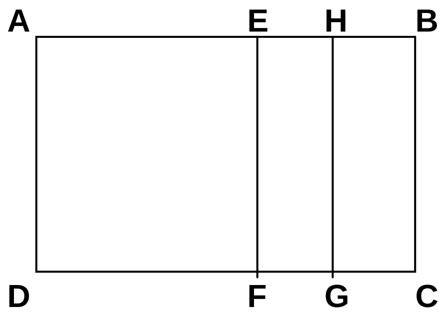
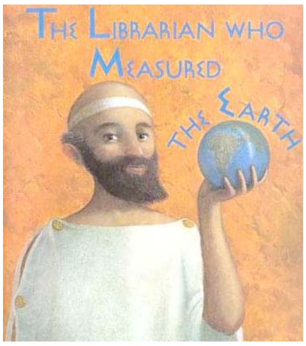


Figure 2

4. Finally, mark your path on the ground: Measure from A to E and from D to F and stretch a string from E to F. Then measure from B to H and C to G and stretch another string from G to H. If the refugees keep between the strings, they will be safe!

Activity F: Finding the radius of the earth

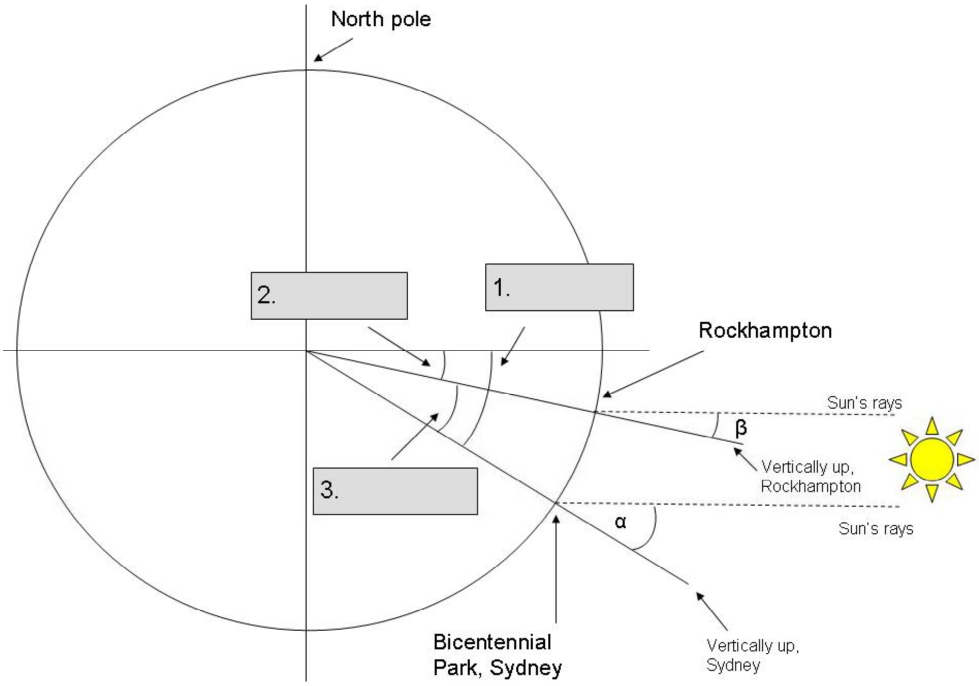
Location: **Outside, where a shadow length can be easily measured**
Duration: **20 – 30 minutes**
Assumed knowledge: **Right-angle trigonometry, ratios**
Equipment required: **Measuring tape, pole of known length**



Introduction: Eratosthenes (276 BC – 194 BC) was a Greek mathematician and astronomer at Alexandria in Egypt. He invented a way to find the size of the earth that uses simple geometry and properties of circles. We have adapted his method for you to use today.

Theory: Angle α in the diagram is the angle between the sun's rays and vertically up at Sydney. This is called the zenith angle. Angle β is the zenith angle at Rockhampton. Eratosthenes realised the planet was round when he found that zenith angles can be different at different places.

1. Assuming the sun's rays are parallel, use your knowledge of angle properties to label the three angles 1, 2 and 3 in terms of α and β.
Question: Why do we assume the sun's rays are parallel?



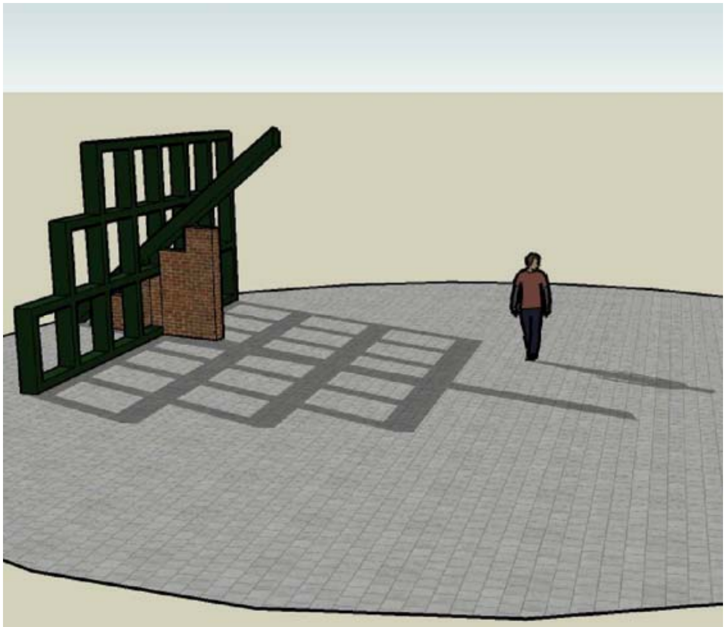
2. Why do you think Sydney was paired with Rockhampton here rather than, for instance, Perth, or Darwin, or Melbourne?

B: Measuring and Calculating

Important Note: The measurements for this activity need to be taken at noon.

Preparation: The surveyor will need to show students how to find out the latitude and longitude at the school's location (possibly using Google Earth). He/she will also need to identify in advance a suitable town on the same meridian as the school, and separated from it by at least 10 degrees latitude. Finally you will need to calculate the zenith angle at the school's location at noon (from the Geoscience Australia web address http://www.ga.gov.au/geodesy/astro/smpos.jsp.), and find the distance between the two locations using a program on the Geoscience Australia website http://www.ga.gov.au/geodesy/datums/vincenty_inverse.jsp.
For people in Sydney, Rockhampton is roughly at the same longitude and 1160 km distant. Similarly, Melbourne to Torrens Creek, QLD is 1889km, Brisbane to Latangai Island, PNG is 2567km and Perth to Belaga, Sarawak, Malaysia is 3810km.

By carefully measuring the height of some object (*h*), (e.g. a pole or stick, or something like the gnomon on the sundial shown here) and the length of its shadow (*l*), use trigonometry to find the zenith angle, α, at your location.



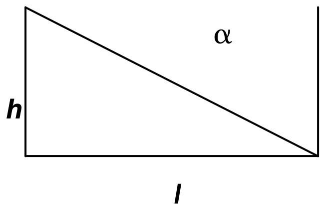
1. Write in the dimensions measured:

h **=** _______

l **=** _______

If there is no sun, your teacher or the surveyor will give you the length of the shadow of a stick 1 m high.

2. Now use some trig to calculate α:



The zenith angle, α = _____

Ask the surveyor to give you the measurement of the zenith angle, β at another town on the same meridian as where you are. β = _____
Or contact sister school who may wish to do the same activity.

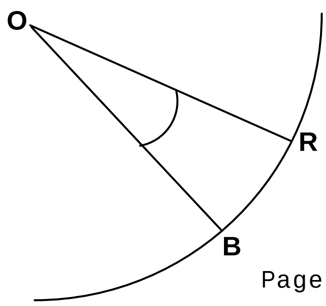
3. The two zenith angles allow us to find the angle BOR, the angle between your location (B) and the other town (R) subtended at O, the centre of the earth (as shown in the theory section).
What is that angle in terms of α and β? _______
What is it in degrees? _______

4. Now that you have calculated angle BOR, look at the sector BOR of the circle.
Ask the surveyor to tell you the distance between the two locations, and use that to calculate the circumference of the circle (i.e., the circumference of the earth).

Show your calculations here:

Circumference of the Earth = _______

5. Radius of the Earth = _______



Activity G: Measuring heights using shadows

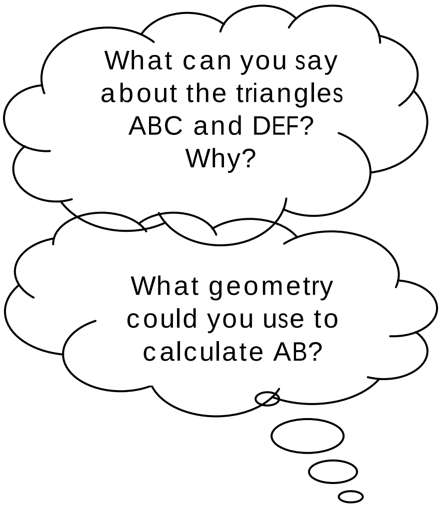
Location: Adjacent buildings
Duration: 30 minutes
Assumed knowledge: Similar triangles or ratios
Equipment required: Measuring tape

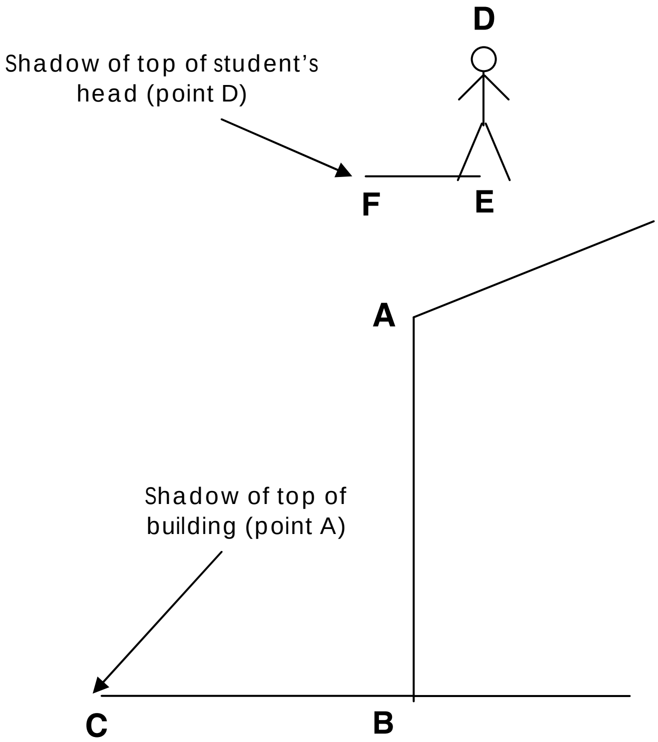
In this activity, you will find the height of a structure where you can't reach the top because it is too tall. You can't just run a measuring tape along it, so you need to be clever, and find indirect ways of finding the height.

1. Find the height of the top of the structure indicated by your teacher. This may be a building, a tree, a flagpole, or some other structure.

You need only a measuring tape.

Ask one of your group to stand upright against a wall. Place a ruler horizontally across their head, and note where it meets the wall. Measure from this point down to the ground to find the student's exact height (DE).
Note where the shadow of the top of the structure falls on the ground (point C).
Mark this point, and measure from the base of the wall to it (BC).





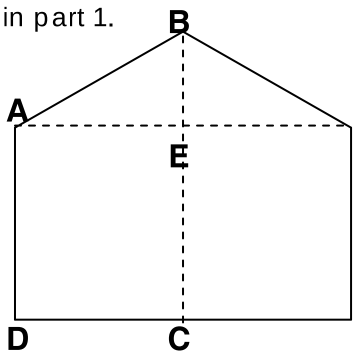
Measure:
DE = ______ m.
EF = ______ m.
BC = ______ m.
Calculate:
AB = ______ m

2. Find the length of the sloping edge of the roof of the building (AB).
Begin by calculating lengths AD and BC (the height above the ground of each corner of the roof), using the same method as you used in part 1.

Measure the distance CD.

Look at the diagram showing the side of the building.

What geometry can you use to find the length of AB?



Activity H: Marking out the corners of a shed

Location: **Open park/field**
Duration: **30 minutes**
Assumed knowledge: **Pythagoras' Theorem, area and volume formulae.**
Equipment required: (for each group of 4 students) 30m tape, plumbob, spirit level, 4 marker pegs. If necessary, makeshift plumbobs can be made using string and a small size weight

Preamble : Surveyors are usually used to set out buildings. There are two reasons for this. Firstly it is important that the building is built in the right shape and that the floor is level. If the building corners are not right angles then it will make it difficult to lay the floor boards, amongst many other problems that will arise. Similar problems will arise if the floor is not level. Secondly the surveyor will make sure that the building is placed inside the boundaries of the block of land. Without the use of a surveyor, it would be much more likely that structures will be built over land boundaries. This would lead to many disputes between neighbours. This exercise allows the students to satisfy the first requirement that the building is both square and level.

Easy exercise

Find a level area large enough to locate a shed 4m long x 3m wide. Students should rotate their jobs so they all get to experience all facets of the shed setout.

1. Push a marker in the ground (this represents 1 corner of the shed)
2. Accurately measure 4 metres with the tape and push a marker in the ground at that location. This represents the 2nd corner of the shed.
3. One student now needs to hold the zero mark on the tape at corner 1. A second student holds the 8 metre mark on the tape at corner 2. A third student holds the 3 metre mark on the tape and stretches the tape tight. Place a marker in the ground at the location of the third student. This is the 3rd corner of the shed.
4. Repeat step 3, with the 3rd student holding the tape at the 5 metre mark. Place a fourth marker at this location, representing the 4th corner of the shed.
5. A surveyor always checks his work is correct. Measure the distance between the 3rd and 4th markers to confirm this is close to 4 metres. Book this reading and see which group gets the best result.

More difficult exercise

Find a site which is sloping. The steeper the slope the harder the exercise. This exercise repeats the above steps and includes a volume calculation. It is important that the first two markers are placed on approximately the same contour on the slope.

1. Push a marker in the ground (this represents 1 corner of the shed)
2. Accurately measure 4 metres with the tape along the same contour as marker 1 and push a marker in the ground at that location. This represents the 2nd corner of the shed.
3. One student now needs to hold the zero mark on the tape at corner 1. A second student holds the 8 metre mark on the tape at corner 2. A third student holds the 3 metre mark on the tape and stretches the tape tight on the downhill side of markers 1 & 2. The third student also needs to use the plumbob, to determine a spot vertically below the 3 metre mark on the tape. The fourth student should use the spirit level near the third student to keep the tape as level as possible. Once the tape is level the fourth student should place a marker in the ground at the location of the third student. This is the 3rd corner of the shed. The third student should hold the plumbob string at the height of the tape. Now use the tape to measure the distance from this point to the bottom of the plumbob. Write this distance down as P3.
4. Repeat step 3, with the 3rd student holding the tape level at the 5 metre mark. Place a fourth marker at this location, representing the 4th corner of the shed. Measure the length of the plumbob and book this result as P4.

5. A surveyor always checks his work is correct. Measure the distance between the 3rd and 4th markers to confirm this is close to 4 metres. Use the spirit level and plumbob if this measurement is not level. Book this reading as and see which group gets the best result. Please note that if the distances measured are not horizontal, the shed will not end up having the correct dimensions of 4m x 3m.
6. Calculate the volume of concrete required to purchase for the floor of the shed. This is done using the end area method.
    a. First calculate the area of the vertical right angle triangle formed by markers 1 & 3 and the floor of the shed. This area A1 = 0.5 (3 x P3).
    b. Next calculate the area of the vertical right angle triangle formed by markers 2 & 4 and the floor of the shed. This area A2 = 0.5 (3 x P4).
    c. The average area over the length of the shed is A(av) = 05(A1+A2).
    d. The volume of concrete required is then the average area of the ends multiplied by the shed's length, V = A(av) * 4.

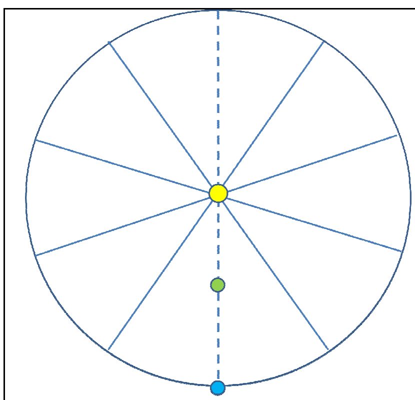
Activity I : Using a paper plate to understand the Transit of Venus

Transit of Venus Activity: Transit Frequency

On June 5-6, 2012, Venus will pass in front of the Sun and we will be able to see this from Earth (don't ever look right at the Sun!). This is a very rare event, and this activity explores why this is a twice in a lifetime event (the last time this happened was in 2004 and was not visible in Montana).

The Race

Imagine that daughter Venus and her mother Earth are going to race around their house. The young daughter, faster of the two, will run close to the house, while Mom will encircle the whole yard further out. As seen from above, they run anti-clockwise (i.e., "planetwise").

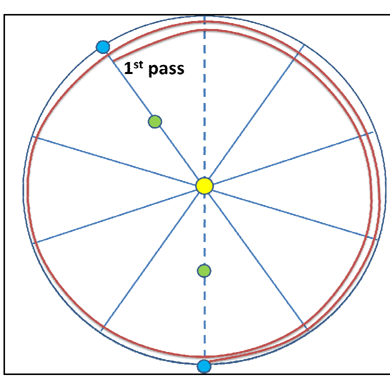


Directions:

1. Draw a dot in the middle of your paper plate for the Sun.
2. Draw a dotted line across the plate and through the Sun.
3. Separate your paper plate into 10 equal segments, as shown in the circle picture. There are about 7 divots in the paper plate per segment.
4. Draw two dots - one at the edge of the paper plate to represent Earth, and one closer to your Sun to represent Venus.

Earth and Venus line up at the dotted line to start the race. "On your mark...get set...GO!" Because daughter Venus is closer to the Sun, she runs around it faster than Mother Earth. Daughter Venus runs one lap in about 8/13ths of Mom's time. (Planet Venus orbits the sun in 225 days; planet Earth orbits the sun in 365 days. Dividing 225 by 365 equals 8/13.)

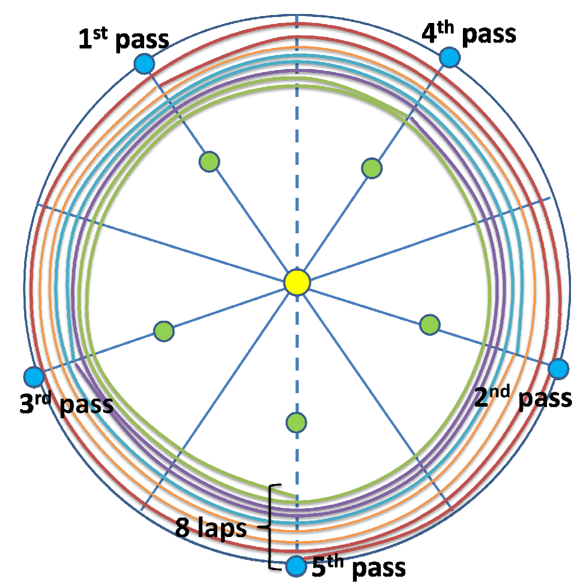
After running only 1.6 laps, mother Earth sees daughter Venus overtake her. At that moment, Mom has completed 1.6 laps while daughter has completed 2.6 laps. Mom notes her and daughter Venus' positions.



Directions:

1. Note that each segment of your grid represents 0.1 laps.
2. Use your grid to trace out 1.6 counterclockwise laps for Earth. Don't bother tracing Venus's path, or your paper plate will start to look messy!
3. At the 1.6 lap mark, draw dots to show that this is where Venus and Earth line up with the Sun.

The race continues. Each time mother Earth completes another 1.6 laps, daughter Venus catches up to and overtakes her on the inside track. Finally, after mother Earth has completed eight laps around the Sun, daughter Venus catches up to Mom for the fifth time. Conveniently, the finish line coincides with the original starting line.



Directions:

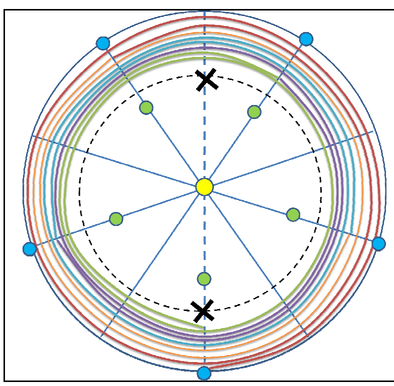
1. From the first pass, use a different color to again trace out 1.6 laps. Again, mark dots to show that this is where Venus and Earth line up with the Sun. **Try to keep your lines separate!**
2. Do this three more times and then you will be back to the starting line, and the pattern starts over again.
3. Count how many times Venus and Earth passed each other – was it 5 times?
4. Count how many total laps you drew around your paper plate – was it 8 total laps?

Mother Earth ran 8 total laps around the Sun in the time it took Daughter Venus to run 13 total laps (which weren't drawn). In that time, Earth and Venus lined up five times.

It would seem daughter Venus passes between mother Earth and the Sun five times in eight years. So why don't we see transits every 1.6 years? Two major factors interfere…

Factor One: The Inclined Orbit

First, daughter and mother are not running on a level surface.

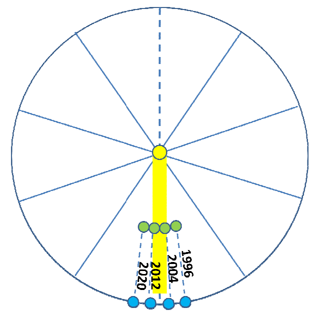


Directions:

1. Leaving the paper plate connected at the straight dotted line (at the X marks), cut two slits just outside the Venus markings but inside the Earth's orbits along the circular dotted line.
2. These hinges (X marks) represent the two nodes, where the planes of the orbits of Venus and Earth coincide.

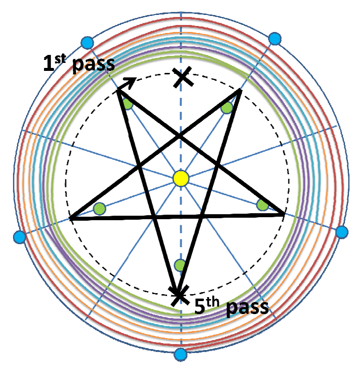
Push the right half of the paper plate down, below the Earth's orbital plane, and the left half up, above the Earth's orbital plane. Only when the Sun, Venus and Earth are in a straight line can we see Venus pass in front of the Sun. The rest of the time, when Venus passes us it is either above or below the Sun from Earth.

Now we see why there are not transits every 1.6 years, but why don't we see transits every 8 years?

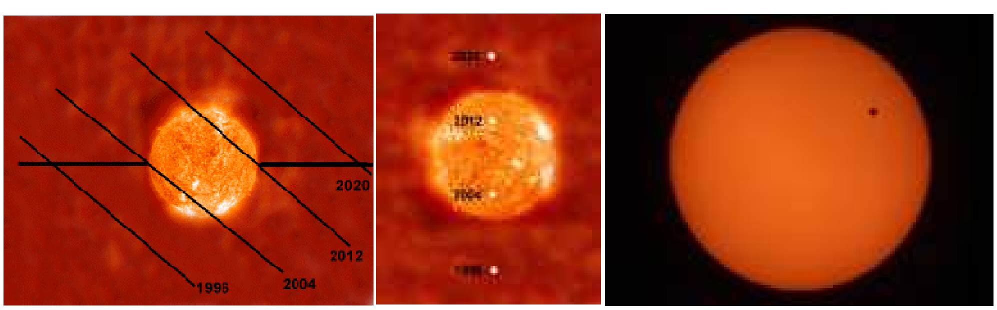


Factor Two: The Orbital Speed

Venus actually makes it to the finish line ***just before*** *mother Earth finishes her 8 laps.*



So each fifth alignment is a little short of the dotted line. The whole five-point star of passes is rotating clockwise a little bit every year. In 2004 the 5th pass alignment was just ahead of the dotted line, and Venus passed across one edge of the Sun, so we saw a transit. In 2012 Venus will pass across the other edge of the Sun for a transit. But after the next 8 year cycle, in 2020, Venus will be too far from the Sun for a transit. We will have to wait until the alignment from the 1st pass shifts all the way to the next node to see a transit again. This will happen in 2117 and 2125, and because the alignment is on the opposite side of the Sun, the transits will be in December rather than June. **That's why transits happen so rarely!!!**

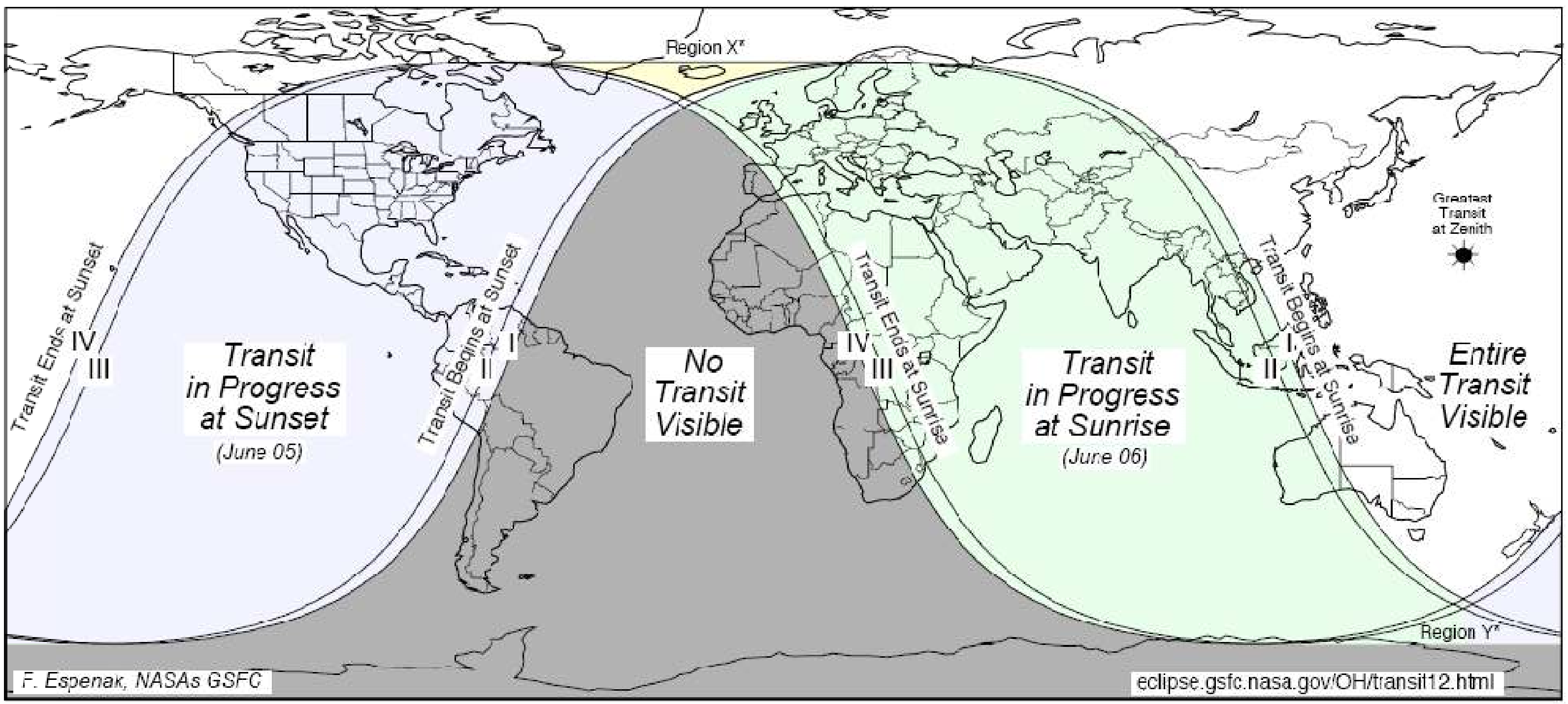


(Not to scale; angles are exaggerated.)

[Note: This activity ignores several important factors, including the eccentricity of orbits, the planet's varying orbital velocity along an ellipse, and precession.]

Adapted from material by Peter Langford and contributed by Chuck Bueter. Diagrams by Kathryn Williamson. Map courtesy of Fred Espenak (NASA GSFC).

Global Visibility of the Transit of Venus of 2012 June 05/06



* Region X - Beginning and end of Transit are visible, but the Sun sets for a short period around maximum transit.

* Region Y - Beginning and end of Transit are NOT visible, but the Sun rises for a short period around maximum transit.

Activity J: Observing Daylight Stars & Planets

Equipment required: **Total station (jigger), Laptop (with battery power), Stellarium software, Step ladder (for smaller children), Clear Sky**

Assumed knowledge: **Nil for the student. A novice daylight star surveyor should see stars within about 5 minutes of setting up his jigger.**

Duration: **30 minutes or less**

> **WARNING: Please be careful not to point the total station towards the sun. If you do, it will burn out the EDM and result in a very expensive repair. You should also NEVER look directly at the sun yourself.**

Pre planning:
Download and install Stellarium on your laptop prior to use from http://www.stellarium.org/. It runs under Windows, Mac or Linux operating systems. Choose a time when Venus, Sirius or Canopus are in the sky and are between 15 and 45 degrees altitude.

Introduction:
Before GPS came of age in the late 1980's, surveyors relied on Astronomy to locate their position on earth and find their bearings. The more remote the location, the greater the importance of fixing the position precisely. Star observations were performed in the evening for obvious reasons. But the stars are all out during the day – only the brightness of the Sun prevents us from seeing them.

A few things are required to find stars during the daytime. These are:

1. The approximate latitude and longitude of the site.
2. The date and time to within a few minutes.
3. A star almanac which gives the location of the stars.
4. A calculator / computer which allows the previous three pieces of information to be input and then calculates the location of the star in the sky at any given instant of time.
5. A telescope, which provides magnification. The greater the magnification, the better you are able to see stars in daylight.
6. The ability to point the telescope very accurately and hold it very steady.
7. A clear sky, devoid of smoke and clouds.

Fortunately surveyors have the mathematical skills and the equipment to find these stars. Only the very brightest stars in the night sky can be seen during the day. The planets Venus and Jupiter are more spectacular to look at than the stars, because they are both larger and brighter. If your eyesight is very good you may be able to see Venus with the naked eye, once you have seen it through the telescope and know where to look.

Today, surveyors can locate their exact position with a GPS receiver in a few seconds during daylight. This used to take hours at night, often in freezing cold conditions. And then more time had to be spent during the day reducing the calculations to get the result. Astronomy is no longer taught to surveyors at University, but to many of the older surveyors it is as precious as a steam train.

Initial use of Stellarium software:
Enter your location. If you are doing a daylight star activity anywhere within about 100km of this location should be OK.
Hit the F6 key to bring up the Location pane. If you live in a large city then you can type it in the top right of the pane and select it. If you don't you will need to type all the details in the bottom half of the pane, select the 'Use as default' checkbox and then the 'Add to list' button.

Basic steps to run a daylight stars session are as follows:

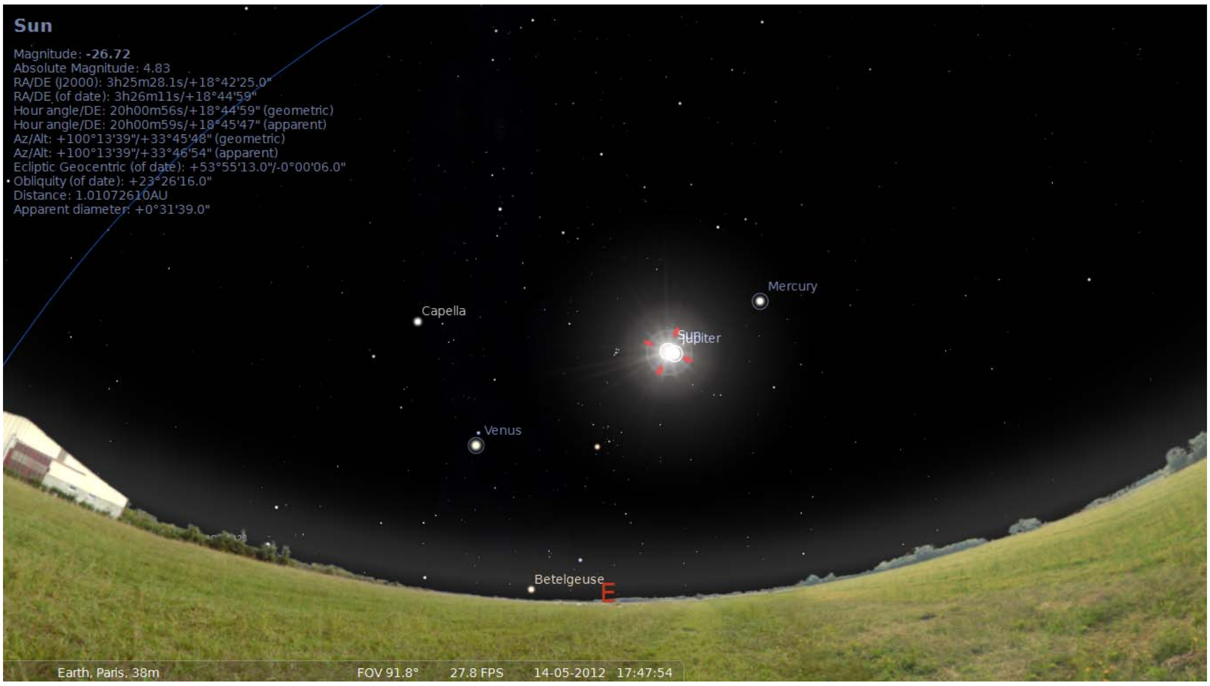
- Setup jigger
- Orient it roughly on the Sun or Moon
- Turn to find a bright planet or star
- Once found, set bearing to that planet or star accurately
- Find other stars and planets instantly

Detailed steps to run a daylight stars session

1. Setup the jigger in a clear location to see the stars and planets you plan to find.
2. Start Stellarium
3. During the day the sky looks blue in Stellarium. To make it look like night and display the star locations hit 'A' on the keyboard. This key toggles between day and night.
4. If the moon is visible, hit the F3 key to bring up the Search window. Type 'Moon' and then hit ENTER. If the moon is not visible, skip to step 8.
5. Note the Az/Alt information at the top left of the screen. For this activity it will not make any difference whether you use apparent or geometric Az/Alt information.
6. Turn jigger to sight the centre of the Moon and set the azimuth from Step 5. If you can orient accurately on the Moon then you can skip to Step 14.
7. If the Moon is too high in the sky, use the gunsight to orient roughly on the moon. Set your jigger to the azimuth from Step 5. Skip to Step 9.

© 2012 Mathematics in Surveying Committee, Sydney

8. If the Moon is not visible repeat steps 4 & 5 replacing occurrences of ‘Moon’ with ‘Sun’. Use the gunsights to turn to the Sun, but make sure you don’t look at it. If the sun is high, set your telescope a little above the horizon so you are looking well below it. If the Sun is low in the sky, set your telescope high so you are looking well above it. Set your jigger to the azimuth from Step 5.



9. Hit the F3 key and search for Venus, the brightest planet, or Sirius or Canopus the brightest stars if possible. If these are not visible, try another star between 15 and 45 degrees altitude with a magnitude less than or equal to 0.
10. Note the Az/Alt information in the top left of the screen. Convert the Altitude to a Zenith Angle, ZA = 90 – Alt for the dummies!
11. Turn your jigger to the Azimuth and Zenith Angle from Step 10. The Sun and Moon are 0.5 degrees in size, so you should not need to search more than 1 or 2 degrees in either direction. Make sure you don’t change the ZA of your telescope. Turn your jigger slowly to make sure you don’t miss the star.
12. You should find the star or planet fairly easily. Venus is much easier than Sirius and Canopus which are pinpricks of light.
13. Once found read the current Azimuth from Stellarium which is constantly updating. Without wasting much time, set your vertical crosshairs on the star / planet and reset your Azimuth. Now you have an accurate azimuth set you can easily find other daylight stars and planets
14. To find others, hit the F3 key, search for the object you wish to find, note the Az/Alt, convert the Alt to a ZA and turn to the object. It should appear in your telescope!

Easy, isn’t it? Happy Star Gazing!

Article 1: Photogrammetry and Laser Scanning

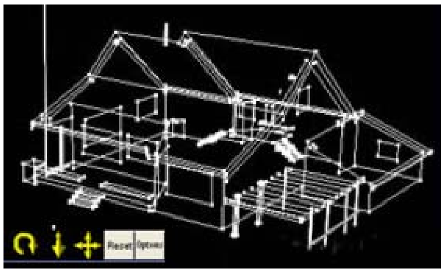
Photogrammetry is a remote sensing technology. Geometric properties of objects are determined from photographic images.

Photogrammetry is used in different fields, such as topographic mapping, architecture, engineering, manufacturing, quality control, police investigation, and geology, as well as by archaeologists to produce plans of large or complex sites quickly, and by meteorologists to determine the actual wind speed of a tornado. It is also used to combine live action with computer generated imagery in movie post-production; *Fight Club* is a good example of the use of photogrammetry in film.

The three-dimensional coordinates of points on an object are determined by making measurements in two or more photographic images taken from different positions. Common points are identified on each image. A line of sight (or ray) can be constructed from the camera location to the point on the object. The intersection of the rays obtained from two or more images determines the three-dimensional location of the point. From this 3D image a model can be consructed.

Photograph 1

Photograph 2



3D image showing key points

Laser Scanning

A 3D Laser Scanner (like the one shown here) analyzes a real-world object to collect data on its shape and possibly its colour. The data can then be used to construct digital, three dimensional models useful for a wide variety of purposes. Laser scanners are used extensively in the production of movies and video games. Other applications include industrial design, reverse engineering and prototyping, computer vision and documentation of cultural artifacts by archaeologists and anthropologists. Many different technologies (e.g., optical, laser, etc.) can be used to build these 3D scanning devices; each has its own limitations, advantages and costs. But there will still be many limitations in the kind of objects that can be digitized: for example, optical technologies encounter difficulties with shiny, mirroring objects, or transparent objects like glass.

The purpose of a 3D scanner is to create a "point cloud" of geometric samples of the surface of the object. These points are used to extrapolate the shape of the object. If color information is collected at each point, then the colors on the surface of the object can be included in the 3D model.

3D scanners are similar to cameras. Like cameras, they have a cone-like field of view, and like cameras, they can only collect information about surfaces that are not obscured. While a camera collects color information about surfaces within its field of view, a 3D scanner collects distance information. The "picture" produced by a 3D scanner describes the distance to a surface at each point in the picture. A single scan will not usually produce a complete model of the object. Multiple scans are usually required, from many different directions, to obtain information about all sides of the object. These scans have to be brought into a common reference system, a process called *alignment*, and then merged to create a complete model.

For further information about these, look up Photogrammetry and Laser scanning in Wikipedia.

Article 2: Sundial

Calculations about shadows are important to surveyors. Applicants for building approvals may ask a surveyor to predict where shadows will fall at different times of year. For example, if a high-rise building was built next door to you, would it cast shade on your backyard swimming pool? Or where should you place solar cells on your roof to get maximum exposure to the sun?

The idea behind sundials is simple. As the earth spins on its axis at a steady speed, it makes one complete turn each day. From our standpoint on the earth, the sun appears to move through 360° in 24 hours, or 15° each hour, and shadows cast by the sun do the same. So we can use the position of the shadow to tell the time. A sundial has a sloping pointer, called a gnomon, and lines drawn on the sundial indicate where the shadow of the gnomon falls each hour. Long before clocks were invented, sundials were used to tell the time. According to archaeologists, people have been doing this for over 4 thousand years.

In the sundial at Bicentennial Park, Sydney,the rays from the base of the gnomon show the time every half hour. The curved lines that cross these rays are parabolas and show the position of the end of the pointer at different times of year. Shadows are shortest at the summer solstice (22 December) and longest at the winter solstice (22 June). The lines beyond the 22 June line are just for decoration.

If you check, you will see that the time indicated by the sundial is not quite the same as the time on your watch. There are three reasons for this. *First*, the earth's path around the sun is not a circle, but slightly elliptical. This causes the length of a day to vary slightly, by about ± 8 minutes. *Second*, the earth's axis is inclined at an angle to the plane of its orbit. This causes the seasons, and it also causes slight variation in the length of a day.
Third, the reference longitude for Eastern Standard Time (EST) is 150°, and the longitude at Bicentennial Park is 151° 4′, causing an error in the time of about 4 minutes. The 150° meridian lies to the West of Sydney. It passes through Marulan, and goes very close to Narrabri, Moree, and Lithgow.

There is a table on the sundial combining these three effects to show the amount to add to sundial time on each date to get EST. Calculating these corrections involves a lot of mathematics. On 19 June it is –3 minutes.

Ancient sundial like one found at Pompeii

Victorian sundial at Winchester, England

Millennium Sundial at UNSW

Article 3: Measuring the Sun and Moon

From Australian Mathematical Sciences Institute (AMSI) "Maths by Email"
http://www.csiro.au/helix/mathsbyemail/activity/sunmoon.html

Try this: How big is the Sun? How big is the Moon?

WARNING: Don't look at the Sun. Looking directly at the sun can cause permanent damage to your eyes.

You will need:

- A small coin
- Some blu-tac
- A ruler
- A tape measure
- Two pieces of paper
- A pin
- An assistant

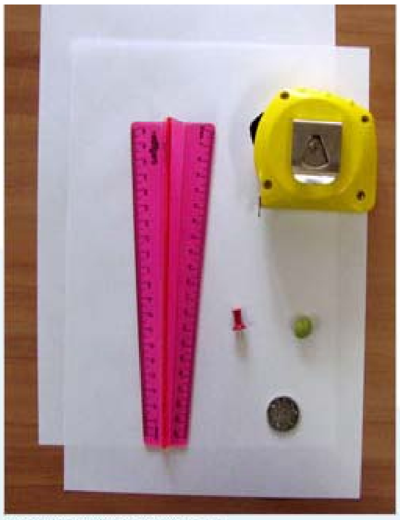


Figure 1: What you will need:

To measure the Moon:

This activity is a lot easier when the moon is full, and when it is rising or setting. Look in your local paper or on the internet to find when the moon will be rising or setting in your part of the world.

1. Use the blu-tac to stick the coin to the top of a pole, or a fence, so it's standing up on its edge. Make sure you can see the moon from where the coin is.
2. Stand with the coin between you and the moon. Move around until the coin looks exactly the same size as the moon. You can check by lining up the coin in front of the moon to make sure the moon is not too big, and then moving forward to make sure it is not too small.
3. Get your assistant to measure the distance from you to the coin with the tape measure. You can repeat this experiment a few times and take the average. convert the distance to millimeters, and call id 'd'.
4. Measure the diameter of the coin (the distance across the round face of the coin), in millimeters. Call the diameter 'w'.
5. This formula will estimate the size of the moon:

$$\text{width of the Moon} = \frac{385,000 \times w}{d}$$

Figure 2: Stick your coin to a fnce or post.

To measure the Sun:

Measuring the Sun is a lot harder than measuring the moon. This is because you should never look at the sun directly. Instead, we can use an image of the sun.

1. Use the pin to poke a hole in one of the sheets of paper.
2. Put the other sheet of paper on the ground, in the sunlight. This piece of paper is the target.
3. Hold the holed paper so its shadow is on the target paper. Move the holed piece of paper until it is about 1 metre from the target paper.
4. There should be a bright dot on the target paper, where the light is shining through the hole in the paper. Get your assistant to measure the distance from the dot to the hole, in millimeters. Call this distance 'D'
5. Then, get your assistant to measure the width (diameter) of the dot. If the dot is an oval shape, measure the shortest line that still goes through the centre of the dot, in millimeters. Call this distance 'W'
6. This formula will estimate the size of the sun:

$$\text{width of the Sun} = \frac{150,000,000 \times W}{D}$$

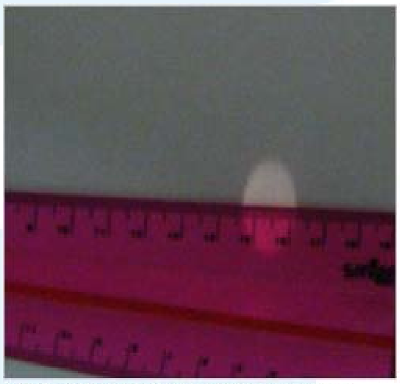


Figure 3: Make sure you measure across the thinnest direction.

Article 4: Finding the distance from the Earth to the Sun

Adapted from an article published by NASA:
http://sunearth.gsfc.nasa.gov/sunearthday/2004/2004images/VT_Activity3.pdf

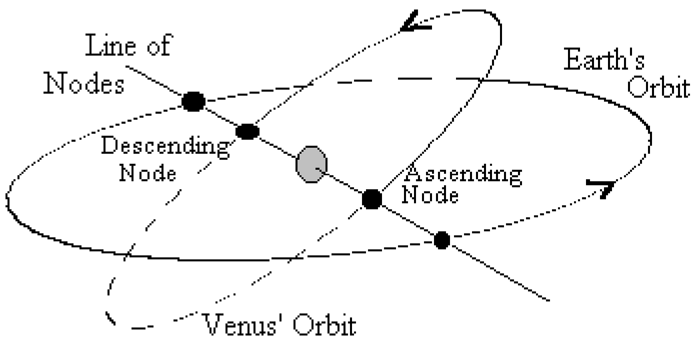
This article is suitable for students who have learned some elementary trigonometry and know about similar triangles. To use it as a student worksheet, delete the answers to questions (i) – (x), leaving blank spaces for students to fill in.

A History of the Transit of Venus

Prior to the 2004 event, the last time humans witnessed a transit of Venus was on December 6, 1882 when it was watched by millions of people across the world, from the crowded streets of Bombay to the deserts of the American southwest.

The first time on record was only 243 years before that in 1639. Johannes Kepler correctly predicted that Venus would pass in front of the Sun in December 1631, but no-one observed it - because it occurred after sunset for most of Europe. Kepler also predicted that Mercury would pass in front of the Sun. Pierre Gassendi observed this transit in Paris a month before the predicted Venus transit. Since Venus and Mercury are so far from Earth, they appear as small dots against the Sun. Therefore, observations of transits were only possible using a telescope - an instrument introduced to astronomy around 1610 by Galileo Galilei. Using Kepler's methods Jeremiah Horrocks managed to predict that a further transit of Venus would occur on December 4th, 1639, 8 years after the one predicted by Kepler. Using a simple telescope to project an image of the Sun on paper, Horrocks was able to observe part of the 1639 transit and become the first human on record to observe this intriguing and rare event.

There is a curious 243-year repeating pattern with two transits in December (around the 8th), eight years apart, then a wait of 121 and a half years, then two June transits (around the 7th), again eight years apart, then a wait of 105 and a half years and then the pattern repeats again. This occurs because Venus' orbit is tilted when compared with Earth's orbit.



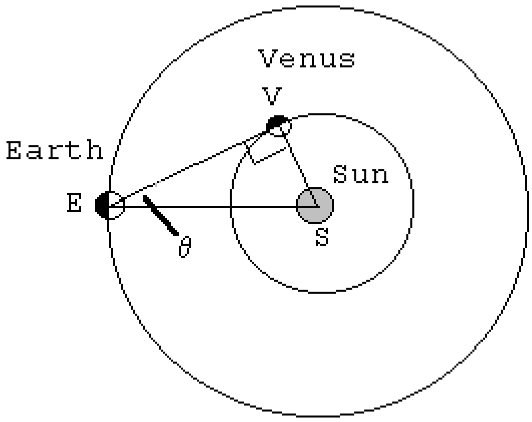
The Transit of Venus may be a rare event, but it has proved important to early calculations of the distance from Earth to the Sun. Knowing the distance from the Sun to Earth allowed astronomers to calculate distances to all of the other planets. Before the critical measurements of the Transit of Venus in the late 1800s, distances in the solar system were expressed in Astronomical Units (AU). But nobody knew what an AU equalled in terms of miles or kilometres. The AU was simply the distance from Earth to the Sun; all distances from the other planets to the Sun were calculated using Kepler's Laws in comparison with the Earth-Sun distance. So astronomers needed to calculate the AU in kilometres!

The next Transit of Venus will be on June 6th 2012. It takes 6 hours to transit and will be seen in it's entirety in the eastern Australian States. Miss this and you will be waiting until 2117 to see the next one!

We can use some maths about Venus' orbit to find distances from Earth within the Solar System

How Far Is Earth From the Sun?
We can apply some simple measurement techniques involving ratios.

Step 1: Simple trigonometry
When Venus appears to us as half in shadow, lines connecting Earth, Venus and the Sun make a right-angled triangle. The following diagram illustrates this, where the side opposite θ is the distance from Venus to the Sun (VS) and the hypotenuse is the distance from Earth to the Sun (ES).



(i) Use SOHCAHTOA to write a trig ratio involving θ, ES and VS:

$$\sin\theta = \frac{VS}{ES}$$

(ii) Rewrite VS as the subject of this equation:

$$ES \times \sin\theta = VS$$

Astronomers have measured the angle θ and found out it was approximately 46.054 degrees.

(iii) Substitute this value into the previous equation to find an expression for VS in terms of ES:

$$ES \times \sin 45.054 = VS$$

$$\therefore ES \times 0.72 \qquad = VS$$

We've shown that VS is 0.72 ES.

When Venus is directly between the Earth and the Sun (when a "transit" occurs), then
$$ES = EV + VS\,.$$

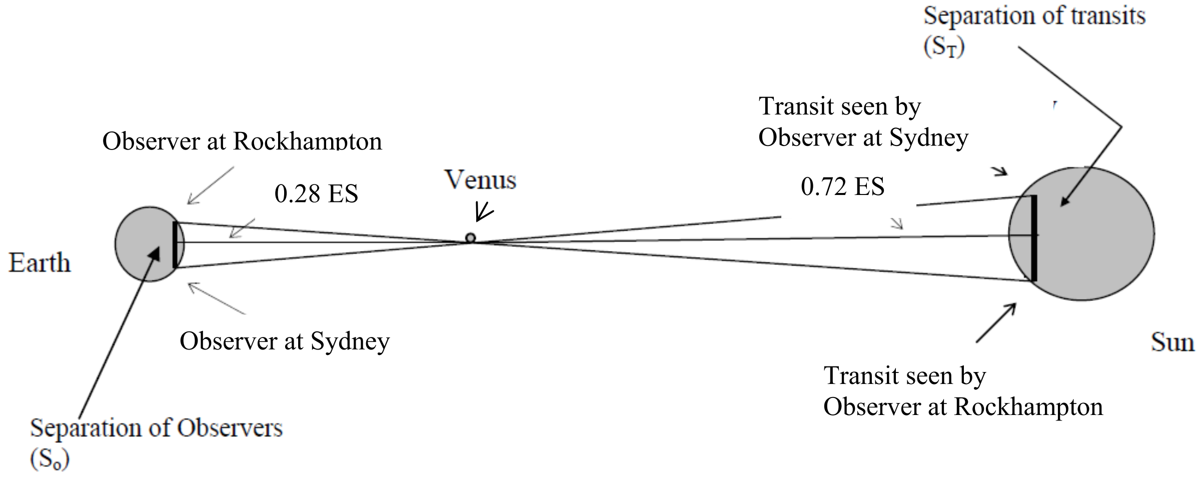
(iv) Using this equation and the previous expression for VS, write an equation for EV in terms of ES:

$$EV = ES - 0.72ES$$
$$EV = 0.28ES$$

© 2012 Mathematics in Surveying Committee, Sydney

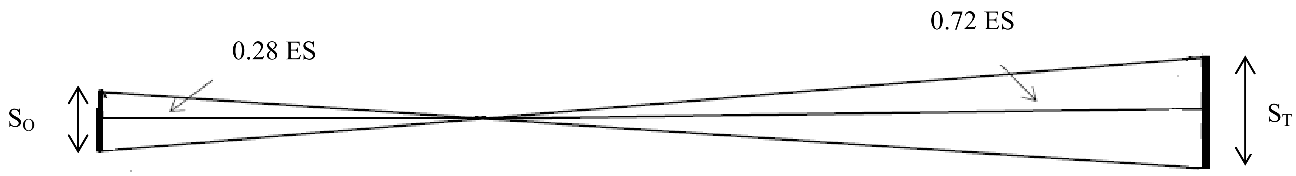
Step 2: Using the Transit of Venus (Part 1)

Now all we need is a transit of Venus and two observers at different latitudes on Earth. Look at the figure below to see how the transit might look (**Note: This diagram is not to scale and the transit separation is greatly exaggerated**).



Before we do any calculations, note that the observer at Sydney (at a location in the more southern part of Earth) will see Venus move across the Sun on a path higher than what the observer at Rockhampton (in Queensland) will see.

The distance between the two observers is labelled as S_O and the distance between the transits they observe on the face of the Sun, is S_T - we'll label these on the two similar triangles.



(v) Write an equation involving these lengths (Using ratios of similar triangles). Make S_T the subject of that equation:

$$\frac{S_O}{0.28ES} = \frac{S_T}{0.72ES}$$

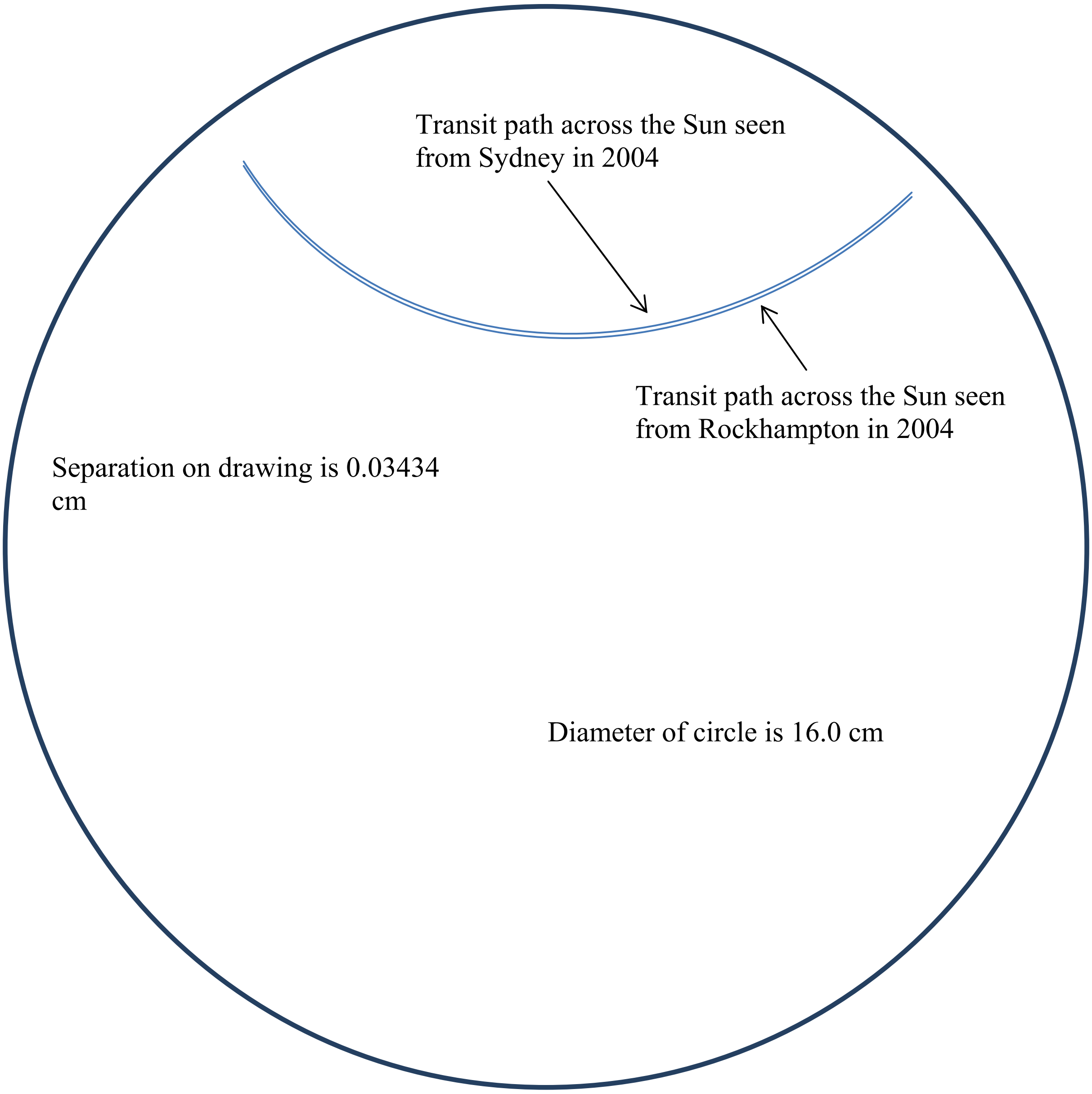
$$\therefore \quad S_T = \frac{0.72ES \times S_O}{0.28ES}$$

(vi) The distance between Rockhampton and Sydney is 1160km (=S_O). Substitute this into the equation above to find the distance between the transits on the face of the Sun (S_T).

$$S_T = \frac{0.72 \times 1160km}{0.28} = 2983km$$

Step 3: Using the Transit of Venus (Part 2)

If you observed the transit of Venus and carefully traced the path of the centre of Venus across the Sun, and if an observer 1160 km north or south of you did the same, you could lay one drawing on top of the other and see the separation. The figure below is approximately what you would see. The two transit paths are in almost the same place – the two lines are only separated by 0.03434 cm.



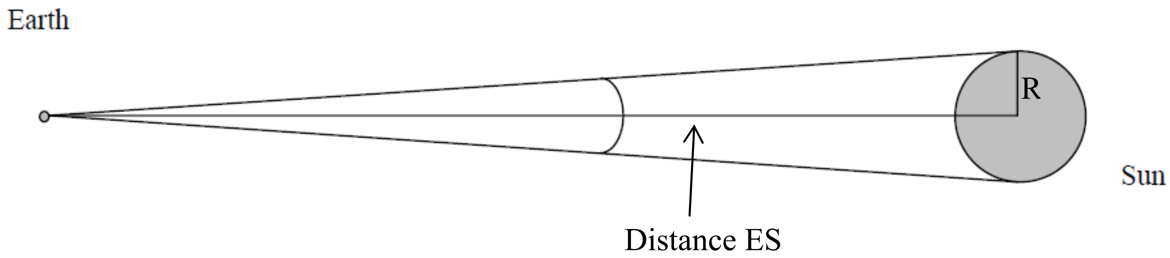
Using this diagram like a scale map of the Sun, we can use the distance between the transit lines and the circle's diameter to calculate the real diameter of the Sun in kilometres:

(vii) Use this ratio to determine the Sun's diameter, to 3 significant figures:

$$\frac{16.0cm}{0.03434cm} = \frac{Sun's\,diameter}{2983km}$$
$$\therefore Sun's\,diameter = 1390000km$$

Step 4: More simple trig

Now ES can be calculated! Consider the following diagram showing Earth and the Sun:



The angle shown has been measured (Google: "the angle subtended by the sun at the earth" to check) as 0.534^0. Note that the half-angle is part of a right-angled triangle, where the Sun's radius is opposite that half-angle.

(viii) Write down the half-angle:

(ix) Write down the radius of the Sun, R:

(x) Write a trig equation involving R and the half-angle leading to the determination of ES (to 3 significant figures).

$$\tan(0.267^0) = \frac{695000km}{ES}$$

$$\therefore \qquad ES = \frac{695000km}{\tan(0.267^0)}$$

$$= 149000000km$$

So now we know the distance from the Earth to the Sun in kilometres.
That is, 1 Astronomical Unit (1 AU) = 149,000,000 km.
Since the distances of all the other planets from the Sun are known in AU, this means we can now calculate these distances in kilometres.

Glossary

Chain:	A 100 metre metal tape (band) used for measurement prior to total stations. The term chain is synonymous with its earlier version, used in the early 20th Century. The chain was made of 100 links and was exactly the length of a cricket pitch and width of most roads today which are all 1 chain wide.
Chainman:	Old term for a Surveyor's Assistant.
Prism:	Glass reflective accessory (size of your first) that is used by a total station to reflect distance.
Range Pole:	A prism is attached to a telescope range pole which is used for location and setout of features. The pole has a height marker so elevation of remote features can be determined in conjunction with the total station.
Theodolite:	Surveyor's instrument used for measuring horizontal and vertical angles.
Total Station (Jigger):	Surveyor's theodolite with inbuilt distance measuring capabilities.
Tripod (Legs):	Three adjustable supports that the total station is attached to for observation.

References/Contacts

QLD

Surveying & Spatial Science – Land Surveying Commission
Website: www.sssi.org.au
Phone: (07)3217 2566
Email: reo.qld@sssi.org.au

VIC

Surveying Task Force
Website: www.alifewithoutlimits.com.au
Phone: (03)9326 8173
Email: trysurveying@alifewithoutlimits.com.au

NSW

The Institution of Surveyors New South Wales
Website: www.surveyors.org.au
Phone: (02) 9264 2076
Email: isnsw@surveyors.org.au

ACT

Surveying & Spatial Science – Land Surveying Commission
Website: www.sssi.org.au
Phone: (02)6282 2282
Email: chair.act@sssi.org.au

SA

Surveying & Spatial Science – Land Surveying Commission
Website: www.sssi.org.au
Phone: n/a
Email: chair.sa@sssi.org.au

NT

Surveying & Spatial Science – Land Surveying Commission
Website: www.sssi.org.au
Phone: (08) 8995 5345
Email: chair.nt@sssi.org.au

TAS

Surveying & Spatial Science – Land Surveying Commission
Website: www.sssi.org.au
Phone: (03) 6272 2034
Email: reo.tas@sssi.org.au

WA

Surveying & Spatial Science – Land Surveying Commission
Website: www.sssi.org.au
Phone: (08) 9386 6601
Email: reo.wa@sssi.org.au

Resources:

Mathematics in Surveying Committee
(Ian Iredale, Mary Barnes, Peter Garside, Beth Campbell, Anna Austin, Nordin Zuber)
Email: marysb@iprimus.com.au

Transit of Venus Committee
Website: www.transitofvenus.com.au
Email: info@transitofvenus.com.au

MiniCAD software may be downloaded for non-commercial, educational purposes from www.mapsoft.com.au or contact Ian Iredale (ian@mapsoft.com.au or 0418 488 342).

Star Prediction Software can be downloaded from www.stellarium.org or via www.transitofvenus.com.au