**Module # 5 – Component # 1**

Navigational Skills Part# 1

**Introduction**

"You have brains in your head. You have feet in your shoes. You can steer yourself in any direction you choose."

*Dr. Seuss (1904 - 1991)*

Navigational skills are the core of navigating. We can have all the tools and instruments in the world, but if we do not have the skills and techniques to use them they are just a bagful of expensive toys.

Skill as a navigator takes ongoing practise over a long period of time. One or two days will not make you an efficient navigator, so practise at every opportunity you can. Even in good conditions when you do not really need the map and compass practise the skills anyway. One of the best ways to learn fast is with personal instruction from an experienced trainer.

This Component will introduce you to a lot of skills and techniques, which can be used on their own or in combination with other skills to navigate efficiently.

These skills are in fact also part of your navigational toolbox.
Estimating Time

There are a number of reasons why we need to be able to accurately determine how long it will take to walk a section of our route. The main reason however is so that we do not try to walk too far in one day, or that we don’t arrive at our destination too early.

Think of the frustration of not reaching your campsite till 10pm, or arriving at 11am and having nothing to do the rest of the day.

Naismith’s rule

The founder of the Scottish Mountain Club, William Naismith, devised a rule of thumb for estimating the time it would take to walk a certain distance.

According to this method, an average adult walker carrying no equipment walks at a speed of five kilometres an hour (12 minutes per kilometre), and a walker carrying a moderate pack four kilometres an hour (15 minutes per kilometre).

To this estimate, 10 minutes per 100 metres climbed should be added for a walker who is not weighed down with equipment and 15 minutes for one who is (two or three minutes per contour line respectively, assuming the contour interval is 20 metres).

This calculation does not take into account rest stops, tiredness, bad weather or any other influences. With heavy packs, it will be found that the basic hiking speed can slow down to two or three kilometres an hour, even for a fit walker.

In reality using a specific set of figures like those above will not work due to all the unforeseen things that can affect your travel. However Naismith’s rule is a useful concept to use, and with practice you will learn to adapt the figures for yourself and your type of walking. We have found that with practice we can generally predict the arrival time on a full day’s walk to within 10 minutes.

We find that in rough terrain we need to change the basic walking speed with a pack to two to two-and-a-half kilometres an hour, but on a good trail like the GR trails in Europe we can comfortably maintain a pace of four to five kilometres per hour, even with a heavy pack.
The group composition will also affect your figures, so learn what works for say a group of children, experienced adults, inexperienced adults, hot or cold conditions, and so on. With practice you will develop your own version of Naismith’s rule.

For purposes of the examples and questions in this Component we have used Naismith’s rule as stated, and assumed the altitude conversion for both up and down conditions. Let’s look at an example:

You need to cover 10 kilometres, and the total height change will be 450 metres. How long will it take to walk this distance, without any stops?

With a pack and walking at four kilometres per hour, 10 kilometres will take two-and-a-half hours.

The height change is 450 metres, so that will mean 4.5 x 15 minutes, equalling 67.5 minutes.

The total time it will take will be 3 hours 37.5 minutes. We usually work to the nearest five minutes.

**How does height change affect distance covered?**

The question often arises around vertical height change and its effect on the distance covered. When measuring on a map we are measuring flat distance and anyone with a remote understanding of geometry will realise that if a significant height gain or loss is experienced then the distance will increase accordingly. In fact this increase is very small and not really worth worrying about.

**The formula to calculate this is:**

Assuming we are walking 10 kilometres and the total vertical height change is 1,000 metres then:

\[
\text{Vertical height change (VD)} = \sqrt{\text{Horizontal distance covered (HD)}^2 + \text{Vertical height change (VD)}^2}
\]

= Square root \((10^2 + 1000^2)\) = 10.049 kilometres

So as you can see, even with a 1,000 metre height gain, the additional distance actually walked is only 49 metres. You will find an Excel calculator to work this out for yourself at [www.navigationalskills.com](http://www.navigationalskills.com).
Tranter’s variation of Naismith’s rule

Although Naismith’s rule has been classed as the classic rule for estimating time, there are a number of variables, such as the fitness of the party, loads carried, conditions underfoot and weather conditions, which Naismith does not take into account. Tranter’s variation to Naismith’s rule takes these into consideration.

To use Tranter’s variation chart it is necessary to first determine your fitness level.

To do this:

1) Measure the time it takes you to climb 300 metres (1,000 feet) over a distance of 800 metres (half a mile) [slope ratio 1:2.6] when fresh and at normal pace with no rest stops.

2) If it takes you 25 minutes then your fitness level will be 25.

The problem with Tranter’s is that most people do not know their fitness level so you end up guessing it, and in a group situation, you would need to know the whole group’s level, so that you could work with the slowest person’s time. This makes Tranter’s chart impractical to use but it still is an interesting concept which clearly shows how conditions effect time taken.

Tranter’s chart takes into account the fitness of the party but when using the chart you would also take into account the following:

- Drop one fitness level for every 13.5 kilograms (30 pounds) carried.
- Drop one or two fitness levels for the type of ground covered and up to four levels for snow.
- Drop one level for low visibility or strong winds.

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<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
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<td>40</td>
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</tr>
<tr>
<td>50</td>
<td>3½</td>
</tr>
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</table>

Tranter’s Chart - www.navigationskills.com
An example using Tranter’s variation chart:

Assuming you were planning a trip of 15 kilometres with a total ascent of 600 metres, according to Naismith, this trip would take four hours.

Then, assuming that our fitness level is 25, if we find four hours on the top of the chart and cross reference it with a fitness level of 25, according to Tranter the trip will take four and a quarter hours. Now if you were also carrying a pack of 13.5 kilograms, you would drop a fitness level to 30, which would mean your trip would now take five hours.

The vertical heights system of estimating time

On a steady steep climb where hands are not being used, it can be assumed that a party will climb between 300 and 500 metres an hour or four to two-and-a-half minutes per contour line respectively.

In this situation, we ignore the horizontal distance. Therefore, if you were going to hike up a pass with a total height gain of 1,200 metres, ignoring rest stops, the calculations would be as follows:

\[
\begin{align*}
1,200\text{ metres} &= 12 \times 100\text{ metres} \\
12 / 300\text{ metres per hour} &= 4 \text{ hours (maximum)} \\
12 / 500\text{ metres per hour} &= 2 \text{ hours 24 minutes (minimum)} \\
or\ &= 60 \text{ contour lines (contour interval of 20m)} \\
1,200\text{ metres} &= 4 \text{ hours (maximum)} \\
4 \text{ minutes per contour line} \times 60 &= 2 \text{ hours 30 minutes (minimum)}
\end{align*}
\]

You will notice that the answers are slightly different, as these calculations are approximate and not intended as an exact indication.

As this method has fewer calculations than Naismith’s rule, it is useful to remember, but do not forget to add your rest stops.
**Estimating Distance**

Once while assisting on a night navigation exercise, I was following two candidates who had identified a steering point about 500 metres from our position where a path crossed a stream. Well, they were so busy talking about how they were going to ace the exercise that they did not even notice the stream. It was about a kilometre later as we topped out onto a hilltop that the two finally realised, “Maybe we have passed the steering point”.

The most difficult terrain over which to estimate distance and time is flat or undulating ground with very few features. The good navigator will have ways to assist with this task. Estimating distance when walking is a fundamental skill, which is especially important when navigating in low visibility. These skills involve a lot of concentration when walking and practice beforehand.

**Timing charts**

A timing chart is simply a pre-prepared list of the times it would take to cover a certain distance at a specified speed. Yes, you could just calculate this in your head, but when tired or cold you may miscalculate.

Naismith’s rule or another suitable method should be used initially to determine your speed over ground on the first leg and thereafter you can use your timing chart. Download this chart from [www.navigationskills.com](http://www.navigationskills.com).

**Example:**

If your first leg takes 10 minutes and is 500 metres, therefore it means you are walking three kilometres an hour.

If the next leg is 400 metres then estimate eight minutes. (Cross reference 3km/h column with 400m)

If the third leg is two-and-a-half kilometres, then estimate 50 minutes and so on. (2 x 1000m + 1 x 500m)
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<th>3km/h</th>
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<tr>
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<td>1¼</td>
<td>1½</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

www.navigationskills.com - Timing chart
Pacing

Pacing is more forgiving than using timing charts as stops or your speed over ground is automatically taken into account, but it is usually only suitable for short distances up to say two or three kilometres.

To use pacing:

1) Measure out a 100-metre distance (possibly use a school athletics track).
2) Starting on the right foot, pace out at your normal comfortable walking speed the 100 metres. (NOTE: Only count the left footsteps and ignore the right.)
3) Pace out the 100 metres again to get the average.
4) The number you have reached is your own 100 metre count. (Remember it!)
5) Using this number, you can easily estimate the distance you are walking when the distance is quite short.
6) Now measure out a one kilometre distance.
7) Collect 10 small pebbles and hold them in one hand.
8) Pace out this distance passing one pebble to the other hand every time you reach your personal count. (See point 4.)
9) At the one-kilometre mark, you should be passing the last pebble. If not, calculate the average error and adjust your personal count – in other words, if you are 20 paces short of the final objective, divide 20 by 10 (legs) and so add two paces to each of your 100-metre legs.

With a bit of practice you will find you can be almost ‘spot on’ with your counting. Remember that over rough terrain it will be necessary to increase your count. By how much will be learnt by experience. It is a good idea initially to work out your personal pacing count over 100 metres in different types of terrain so that you can realise how different terrain affects your pacing count.

While leading groups, it is a fun exercise to teach this skill to party members. Have competitions to see who can be the most accurate to a fixed point during the hike and check the winner using your map. It also helps keep rowdy hikers quiet, as they are so busy counting. An alternative is to buy a pedometer that counts your steps as you walk and calculates the distance covered. Pedometers are also affected by changing stride length so remember to take this into account. The Omron® pedometer also has great software so you can download your steps to your computer and work out a whole range of statistics such as energy consumption, fat burned, distance covered etc. www.omron.com.
**Conditions underfoot**

The conditions underfoot or conditions of the terrain will affect the accuracy of your pacing and estimates of the distance covered. If you are covering rough boulder-covered terrain it will cause you to over-estimate the distance covered, as you will have been taking smaller steps, so you must increase your personal pacing count.

The extent to which the conditions underfoot affect your pacing will vary in different situations and it will take experience and practice to determine by how much you should adjust your estimates. Adjustments can be made along these guidelines:

- **Clothing**: Excess clothing and boots with poor traction affect the pace length. (Add extra paces.)
- **Elements**: Falling snow, rain or ice cause the pace to be reduced in length. (Add.)
- **Slopes**: Your pace will lengthen on a down slope and shorten on an upgrade. Keeping this in mind; if it normally takes you 60 paces to walk 100 metres, your pace count may increase to 65 or more when walking up a slope.
- **Surfaces**: Sand, gravel, mud, snow and similar surfaces tend to shorten the pace. (Add.)
- **Visibility**: Poor visibility, such as in mist, rain, or darkness, will shorten your pace. (Add.)
- **Winds**: A head wind shortens the pace so add steps and a tail wind increases it so subtract steps.

The scale is loosely based on the Yosemite scale and has been adapted to be more specifically descriptive and useful for walkers.

On a scale of one to five, each terrain type is described based on the speed you could expect to travel as well as the type of steps and dangers that may be experienced. This then provides someone going to the area for the first time a good idea as to what to expect.

Each level may include all the elements of the previous levels and for a trip to be classified at a level, at least 10 percent of the trip must involve those conditions. A Class + trip means that it is the class specified, but there may be small sections (less than 10 percent) of the next higher level – for example, Class 3+. Snow, rain, wind, darkness and other factors could increase any level to the level above.
Class 1 (4-5km/h average)

- Walking along a clear, well established trail.
- Could be some erosion to negotiate.
- May be wet areas with mud.
- A few rocks or steps in path may be encountered.
- Easy to moderate slopes.

Class 2 (3-4km/h average)

- Walking along a sometimes obscured trail.
- Will be some boulder hopping to cross rivers and other obstacles.
- Hard compacted snow.
- Moderately steep slopes.
- Easy cross-country travel (bush, climbing over and around fallen trees, and big talus – hands may be used for balance).

Class 3 (2-3km/h average)

- The trail is either very uneven, intermittent or non-existent, and you may need to put your hand down once in a while for balance.
- Soft slushy snow not above ankle.
- Requires use of hands for climbing steep sections.
- Rope is necessary only to provide safety in unusual circumstances.

Class 4 (1-2km/h average)

- Climbing on steep terrain, perhaps requiring roped belay or rope handrail in sections.
- Scrambling on rocks using hands as well as feet.
- Exposed climbing such as a ladder.
- Snow slopes requiring kick-stepping.
- Glacier walking.
- Rope required to prevent serious injury if a fall occurs.
- Head for heights required in some places.

Class 5 (<1km/h average)

- Climbing on steep terrain requiring roped belay.
- Safety rope must be used for exposed sections.
- Thin, exposed areas requiring skill and good balance as well as a head for heights.
Orientating The Map

I met two hikers just south of a major pass who were heading for a local peak. When asked why they were walking south, (the peak is north from that position), they replied that they still had a way to go before reaching the peak. After further discussion, I asked them to show me where they thought they were on the map. The reason for their confusion was clear. They had the map orientated upside down.

In good visibility conditions, most navigation is carried out visually without the use of a compass. This we call terrain association navigation. To effectively navigate in this manner the map needs to be orientated or turned so that it is correctly aligned with the earth. There are two main methods to achieve this.

Using visual terrain association

A map can be orientated by visual terrain association when a compass is not available or when the user has to make many quick references as they move across country. Using this method requires careful examination of the map and the of the map and the ground, and the user must know the approximate location.

1) Look for at least two identifiable terrain features such as hills or road inter-sections. These should ideally be about 90 degrees apart from your viewpoint.
2) Locate these two features on your map.
3) Turn the map till the features on the ground are aligned with the features on the map. The map is now orientated.

Once you have orientated the map, it is possible to locate the relative position of the features around you. This is approximate and not as accurate as using a compass but is an important basic skill. In practice, this method is more often used than a compass.
**Using a compass to orientate the map**

Having just learnt to set a map visually and also discovering that this was not entirely accurate but gave an adequate setting, we now use the most accurate method for setting a map using a compass. When orientating a map with a compass, remember that the compass measures magnetic bearings.

Since the magnetic arrow points to magnetic north, pay special attention to the declination diagram.

1) Lay the map out flat.
2) Set the orientating north arrow of the compass to the magnetic declination.
3) Place the compass on the map with the direction of travel arrow pointing north along the true north lines.
4) Gently rotate the map and compass together until the needle coincides with the orientating north arrow.
5) The map will now be set in relation to the land.

Having orientated the map with a compass, you can now visually locate your own position and the position of the features around you by comparing features on the map with terrain features around you.

Special care should be taken when orientating my map with a compass. A small mistake could cause me to navigate in the wrong direction.
Calculating Bearings

What are bearings?

Also referred to as an azimuth, a bearing (we discussed this in a previous Component) is defined as a horizontal angle measured clockwise from a north base line. This north base line could be true north, magnetic north, or grid north.

The bearing is the most common method of expressing direction. When using a bearing, the point from which the bearing originates is the centre of an imaginary circle. This circle can be divided into 360 degrees, 6,400 milradians, or 400 grad amongst other lesser grading systems.

For the practical purpose of this Course, we will in future assume you are using equipment measured in degrees.

Bearings are used to indicate direction on a map or with a compass. The bearing will either be true, grid or magnetic, depending on whether the measurement was taken from true, grid or magnetic north respectively. When working on a map your north reference will be grid north as its base line, therefore the bearing will be a grid bearing. When using the compass to sight a bearing the compass is using magnetic north as its base line so the bearing will be magnetic.

“Even with the best of maps and instruments, we can never fully chart our journeys.”

Gail Pool
Calculating bearings on a map

To obtain a grid bearing from a map:

1) Place the compass so that the edge of the compass is lying along the line or route for which you wish to obtain the bearing.
2) Turn the compass housing till the orientation lines in the compass are parallel to the grid lines of the map. This is the grid bearing of the line or route.
3) Ignore the magnetic needle as you are using the compass as a protractor.
4) Read off the bearing indicated at the index mark.
5) This is the grid bearing of the line or route.

Sighting bearings with a compass from a feature

To obtain a magnetic compass bearing from a feature:

1) Hold the compass flat in your hand with the direction of travel arrow pointing towards the feature concerned.
2) Wait until the needle has settled.
3) Turn the compass housing until the orientating north arrow is directly under the north end of the needle.
4) Read off the magnetic bearing at the index mark.
Conversion of Bearings

We know that bearings obtained using a map will be grid bearings, but if obtained using a compass by sighting onto an object they will be magnetic.

When, for example, if using bearings calculated from a map (grid) to sight a direction of travel, it is vital that they are first converted to magnetic as you will be using a magnetic compass to sight with. This uses magnetic north as its base line instead of grid north, which you used when determining the bearing from the map. If you don’t, your route will be inaccurate by an amount equal to the magnetic declination. This is probably the most common mistake made by navigators.

When magnetic north is west of true north (west declination)

When magnetic north is to the west of true north, to convert grid bearings to magnetic bearings you must ADD the magnetic declination, and to convert magnetic bearings to grid bearings you must SUBTRACT the declination. An easy way to remember this is to think that when converting a grid bearing you are lifting it from a small map to the big earth so you ADD and vice versa.
When magnetic north is east of true north (east declination)

![Diagram](image)

When magnetic north is to the east of true north, to convert grid bearings to magnetic bearings you must **subtract** the magnetic declination, and to convert magnetic bearings to grid bearings you must **add** the declination. An easy way to remember this is to remember the well-known rhyme: ‘From grid to mag add, and from mag to grid get rid’.

**Example for west declination:**

Assuming you have made a sighting with your compass onto a feature and have determined a bearing of 320 degrees, you now wish to mark it on your map. Subtract the known declination of say 20 degrees (check what it is on your map for your area) and you now have 300 degrees.

If you had determined the bearing from the map (300 degrees) and now want to walk in that direction following your compass you would have added the 20 degrees to make 320 degrees, which would be the correct direction to walk in.
Errors and their results

Errors of distance and direction are the two main problems in navigation. Incorrect bearings or reading the map the wrong way around usually cause direction errors, and distance errors are caused by inexperience, trying to take short cuts, difficult terrain and fatigue.

There are many causes of direction errors but the most common are:

- Metallic deposits in the ground causing interference with the Earth’s magnetic field.
- Power lines, metal objects in your pockets, fences, or any other metal in your vicinity.
- Holding the compass at an angle.
-Aligning the south end of the needle with north (common).
- Forgetting to convert for magnetic bearings and true bearings (common)
All walkers make some degree of error when sighting a bearing. An experienced walker will possibly make an error of half a degree while beginners are usually about three degrees out, but can be as much as 180 degrees out by aligning the wrong end of the magnetic needle with north.

Errors in converting bearings or simply forgetting to make the conversion will cause your route to be off course by an amount equivalent to the magnetic declination, with possible disastrous consequences.

An error of 20 degrees will, over a one-kilometre distance, result in your being approximately 347 metres off course. A simple three degree error will result in a 52 metre error.

Errors of direction are probably the most common mistake made by users in the outdoors.