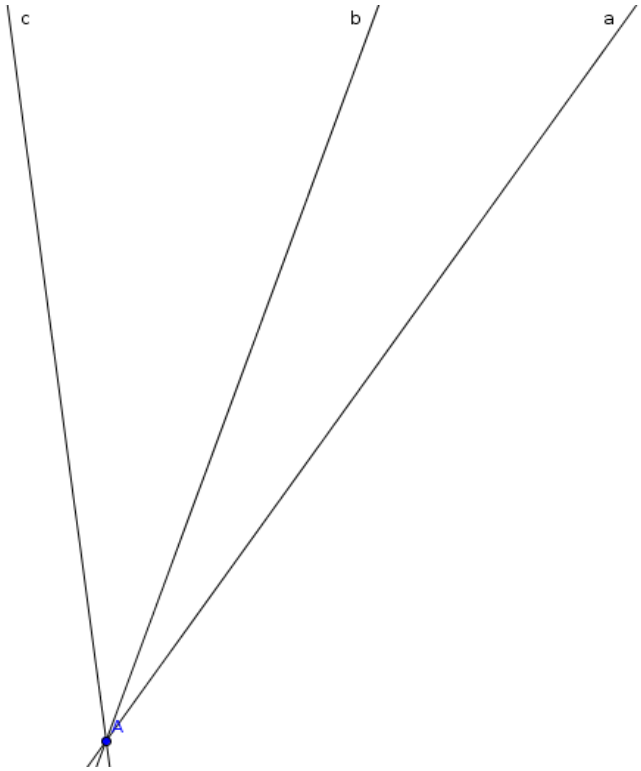
THE FOUR BEARINGS METHOD

Given four non parallel bearings, taken at known time intervals, to a target at constant course and speed, it is possible to deduce those and its position. I have searched the internet for info on how to compute solutions on the chart but what I have found is either more complex than it should or plainly wrong, so I have been doing my bit of thinking and devised what I consider to be the proper way to go. I don't believe in property when it comes to solve mathematical problems so there is no acknowledgement of sources or distinction between my own findings and those of others. You may use this document in any way you like, and that includes making your own version to improve on my English. I have put this together to make my modest contribution to a community that has given me so much, along all those years of Silent Hunting. Thank you, people.

Even though is possible to compute solutions for any combination of time intervals between bearings, taking them at equal periods simplifies computing a lot, and we will assume that throughout this document.

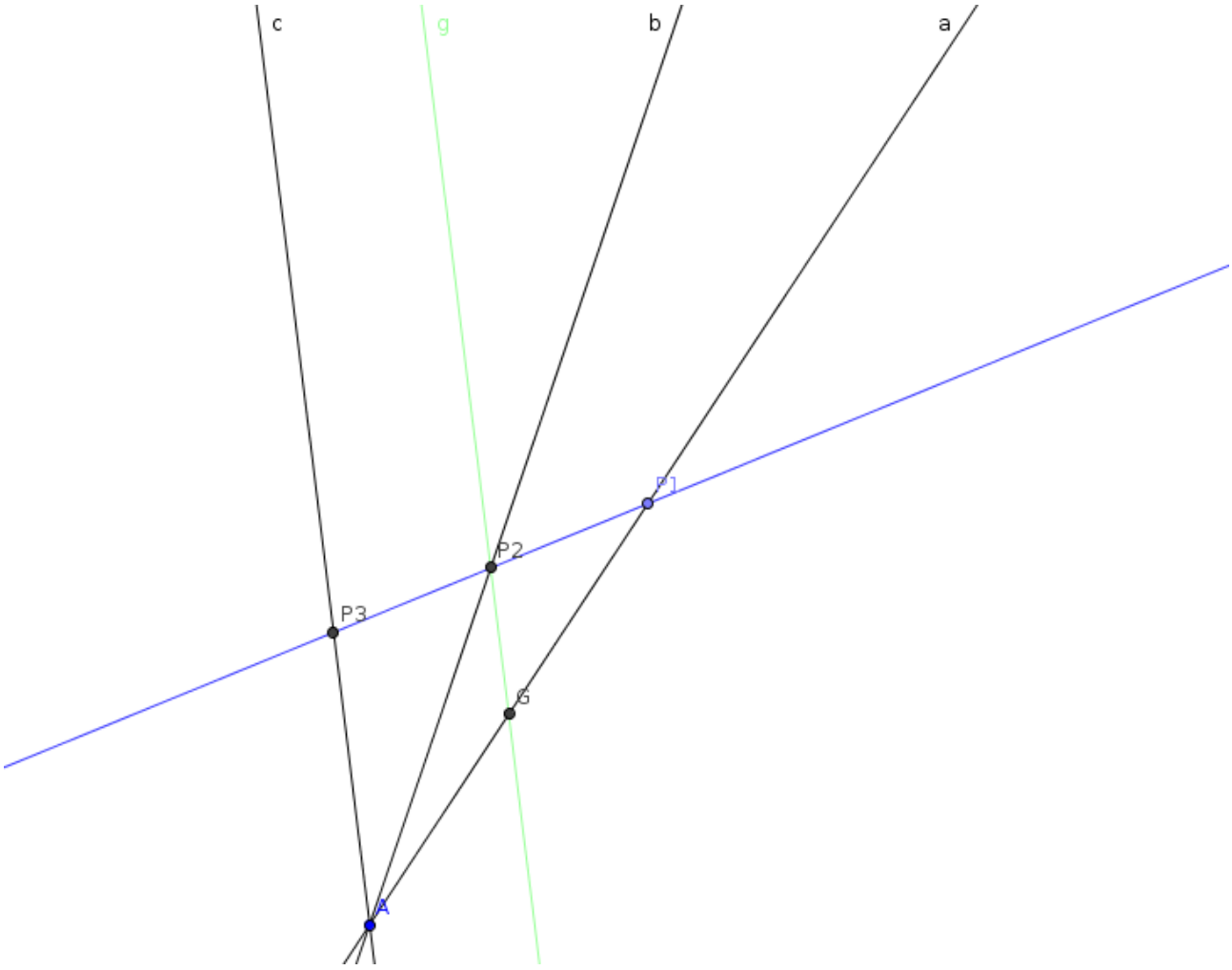
Special case: submarine is not moving

Consider this schema, where *A* is the position of your ship, not moving, and *a, b* and *c* are three successive bearings.

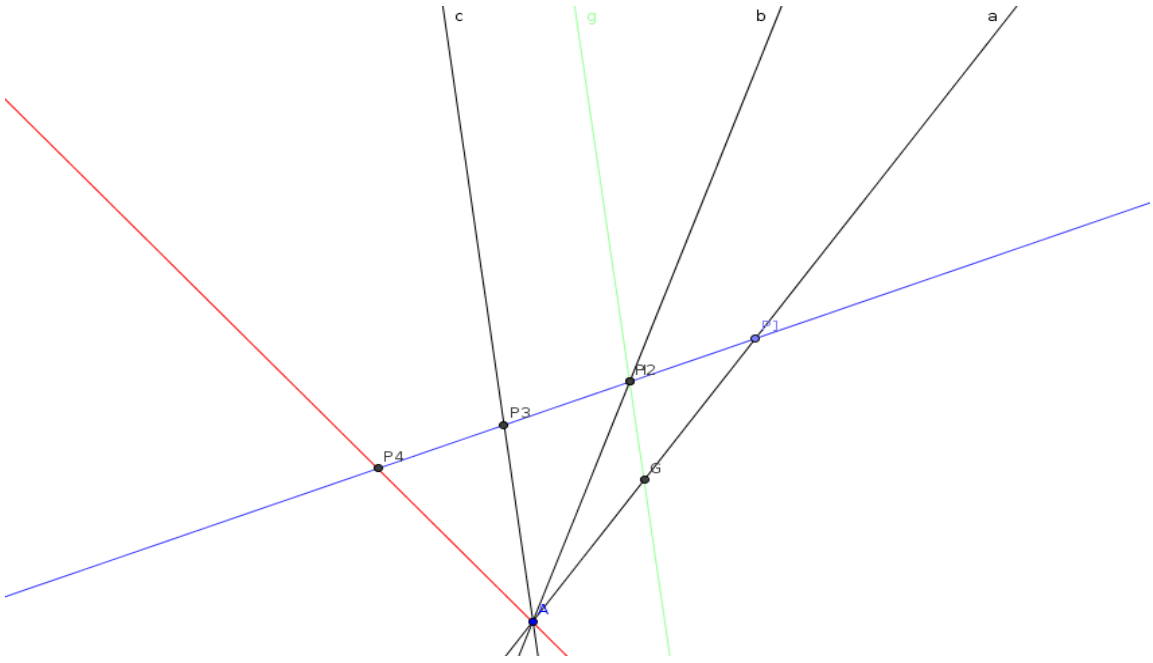


With this information it is possible to compute the course of the target. Thales theorem comes in handy:

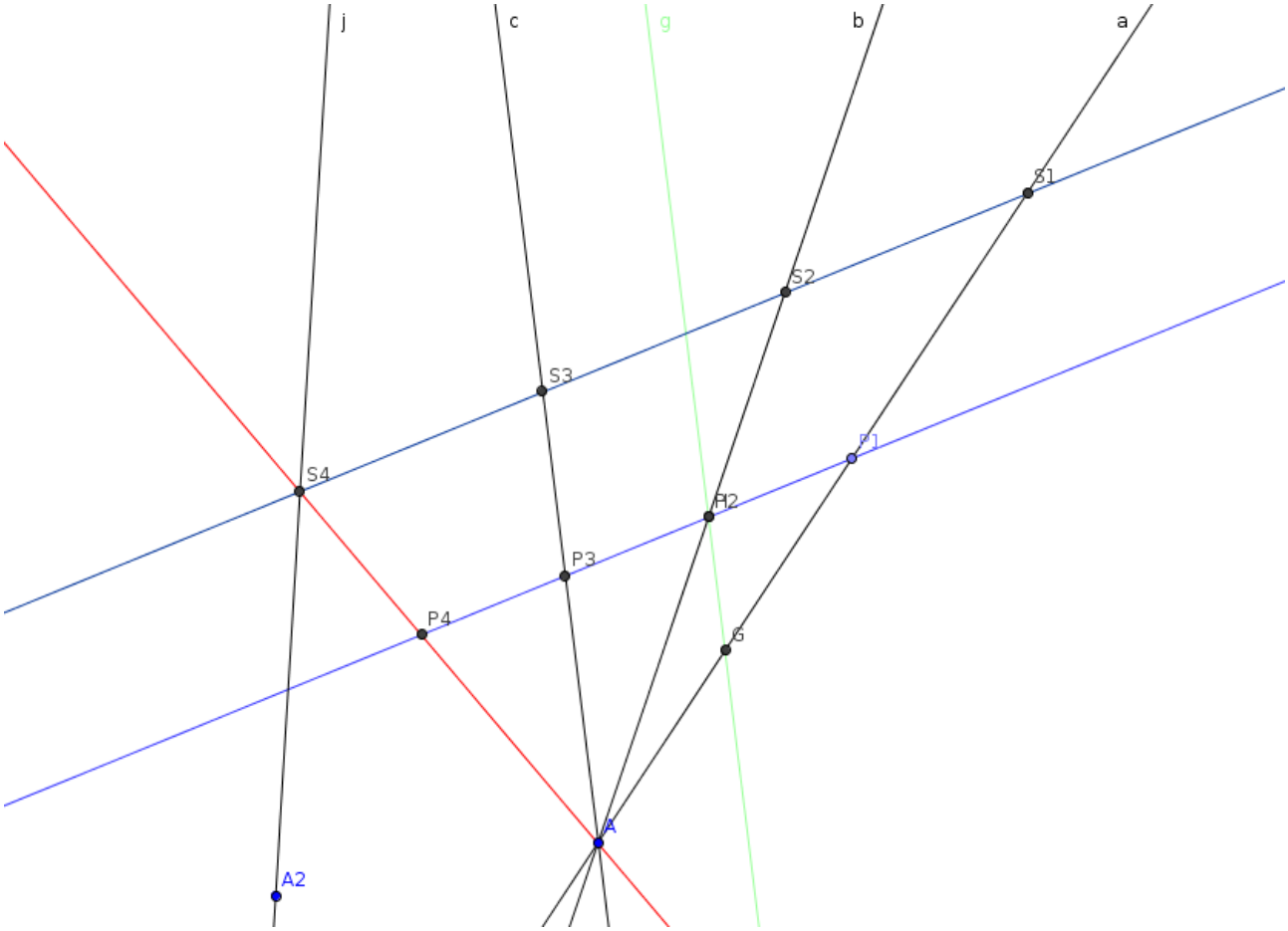
Choose a point *P1* along *a* and find the middle point *G* between *P1* and *A.* Then draw a parallel to *c* through *G* that will cut *b* at *P2*. Now the line determined by P*1 and P2* is the course of the target because for any *P1* you choose, the slope of that line is the same and the distance between *P1* and *P2* equals that between *P2* and *P3.*



Now we need a four bearing to find speed and position of target, but a bearing from *A* will not add any information. In fact, we already know what next bearing will be: find *P4* along the estimated course by protracting distance between *P2* and *P3* and draw the expected bearing from where you are, (in red):



Now move your ship to a new position *A2* and take a fourth bearing. This will cut the expected bearing at the real position of target, *S4.* Draw a parallel to your first estimated course through *S4* and you have all you need to compute speed.

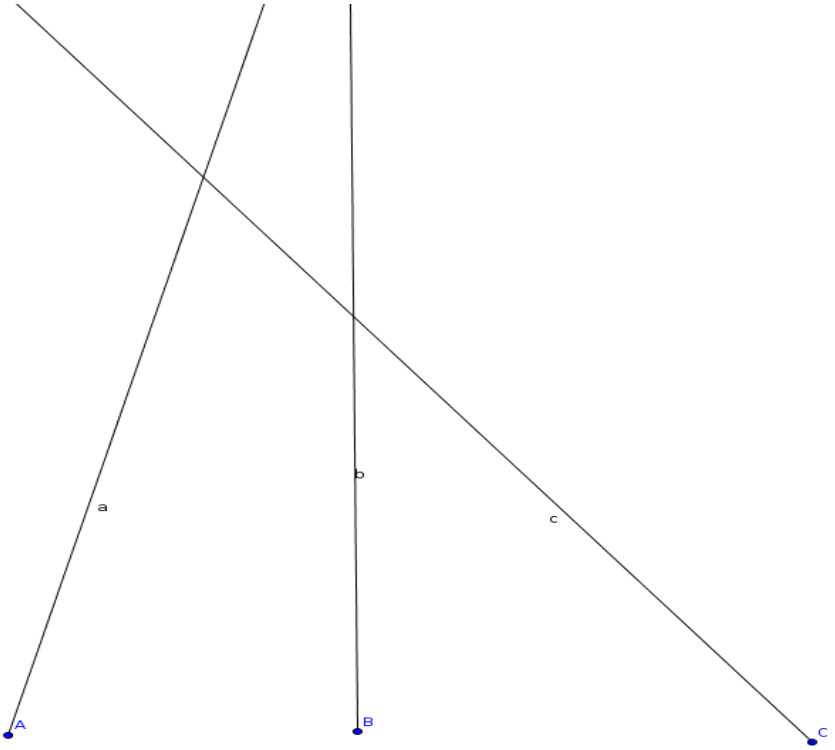


This works because the first three bearings meet at the same point *A*, but there are problems. First of all, a ship has to be moving to keep orientation. In the game, a full stop will keep your ship fixed but that is not realistic. The sea is not static: currents can be as fast as to keep you in the same spot while you are steaming half speed ahead; a ship without propulsion will spin helplessly unless anchored and even then. But the main problem is that you may have a very narrow window of opportunity or none at all if you don't move. In some situations you may be steaming slow, say one knot, and taking bearings at short intervals. In that case you can assume that your solution will be a good approach to the real situation using this method. You'll have to assess the accuracy of your solution and maybe refine it with further bearings or other measures.

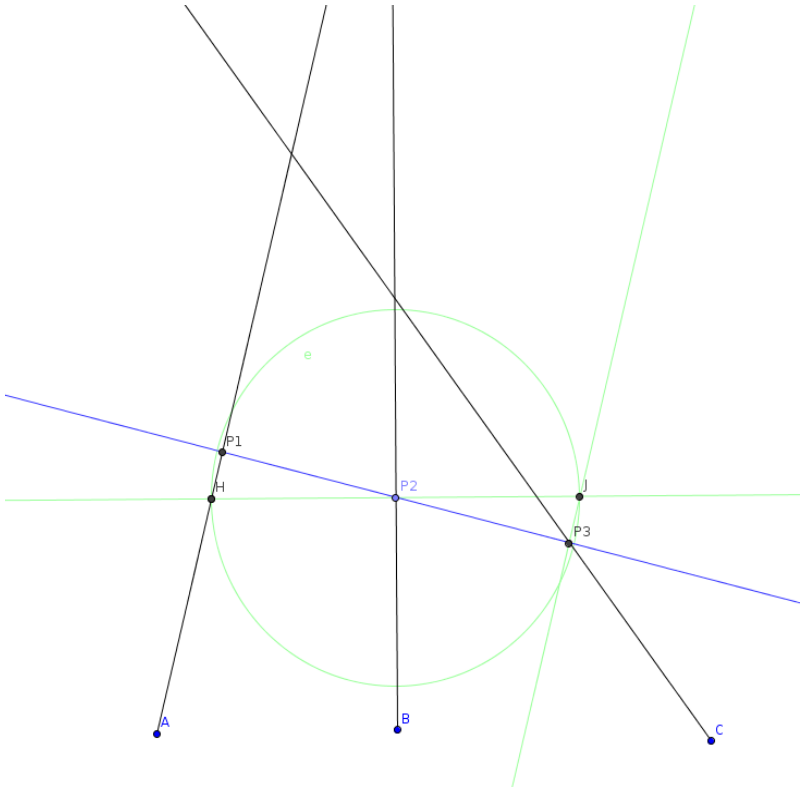
General case: you are moving

When you are moving bearings do not cross in general at the same point, which renders the procedure described above useless, the more so the faster you go and the longer the time interval is. We will need an alternative method of finding an estimated course without the reference of that point. Our first problem is: given three arbitrary bearings, to find a course that cuts them at equal distances. Here is how to proceed:

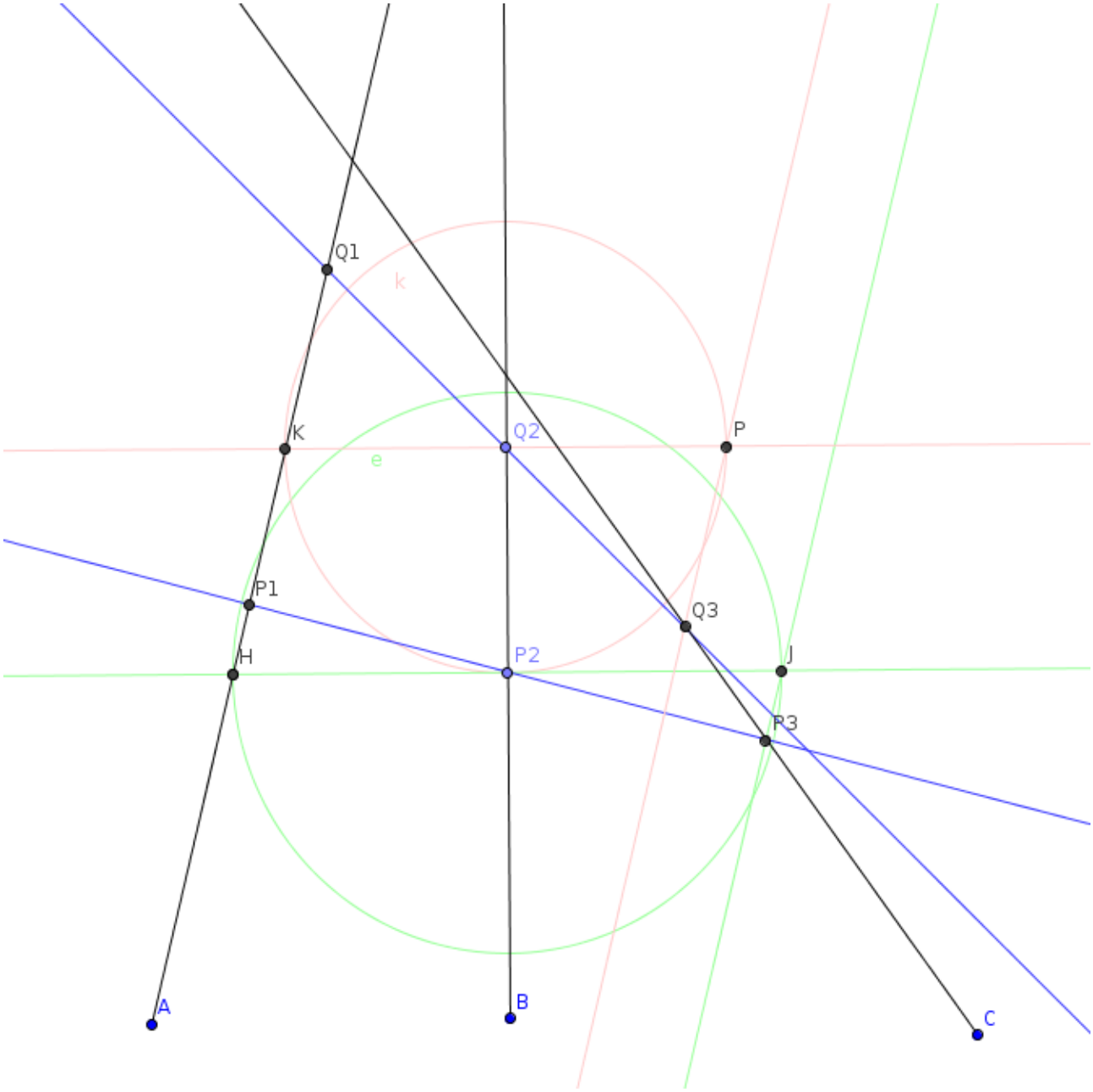
Consider this situation, where you have taken bearings at points *A, B, C*:



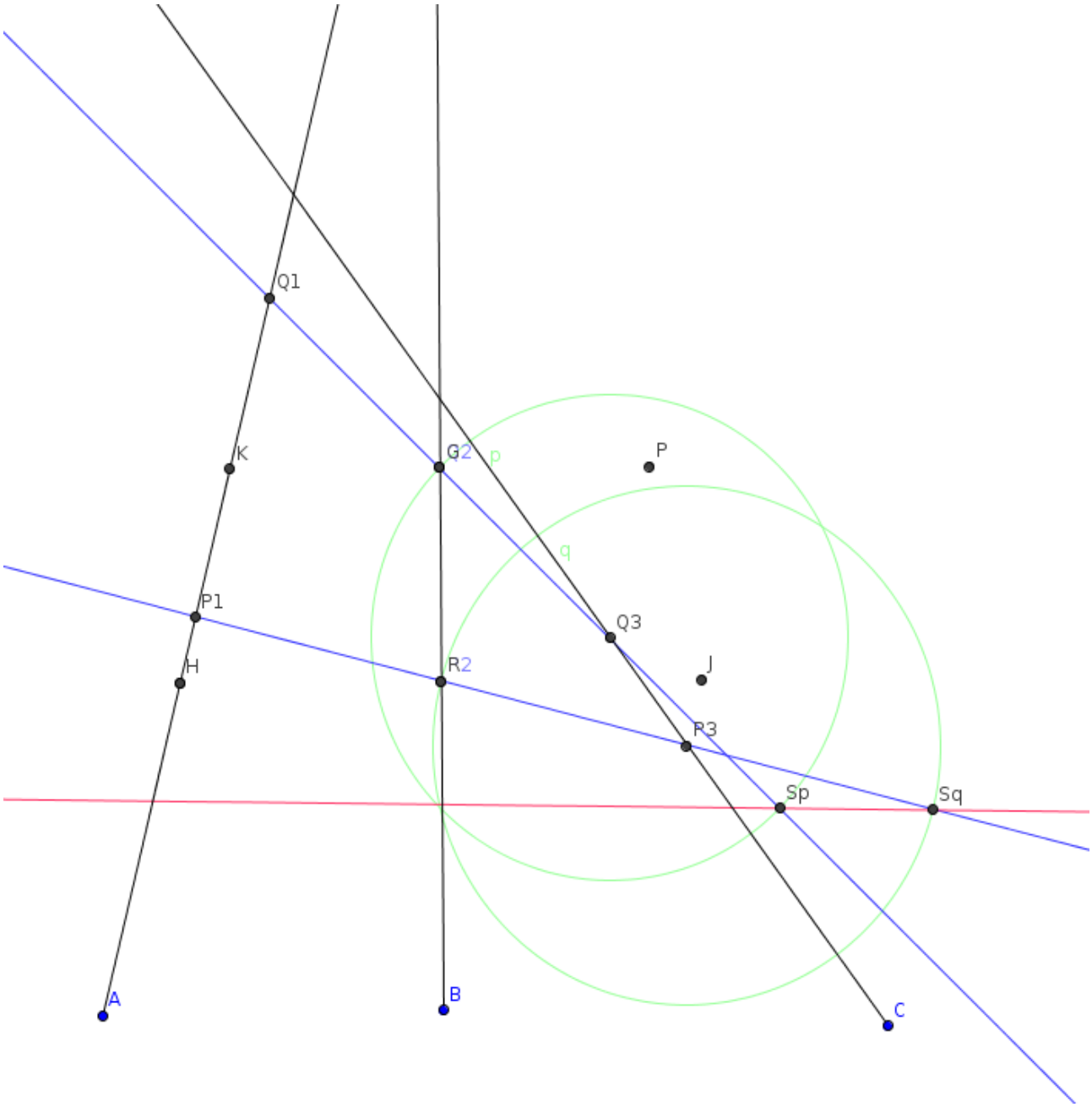
Take any point in the second bearing, *P2*, and draw a perpendicular through it. This gives you *H*, at the first bearing, and its symmetric point *J,* with respect to *P2*. Now a parallel to first bearing through *J* gives you *P3* and joining this with *P2* gives *P1* and a possible course for your target, (in blue).



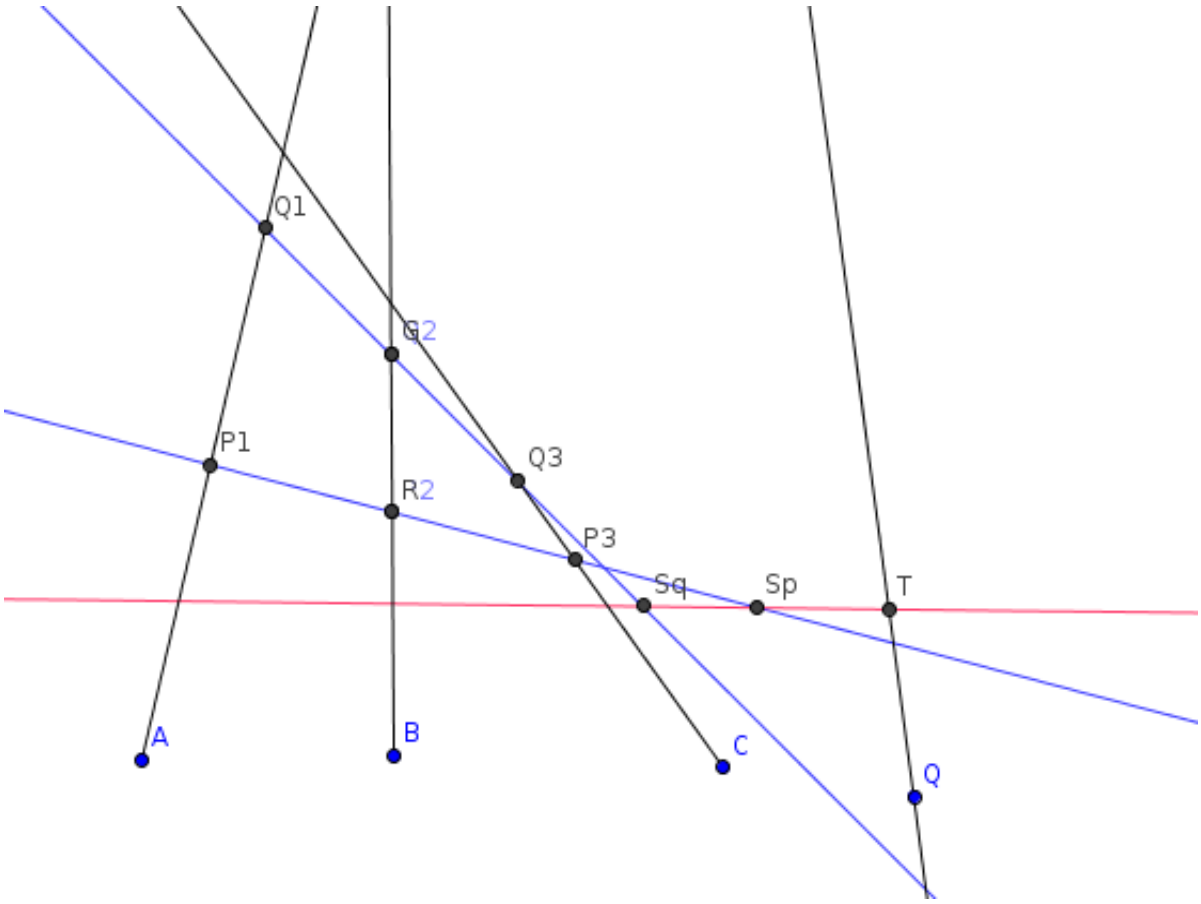
Repeat for any other point along the second bearing, at some distance. As you can see, solution courses can vary wildly, depending on your initial point of choice.



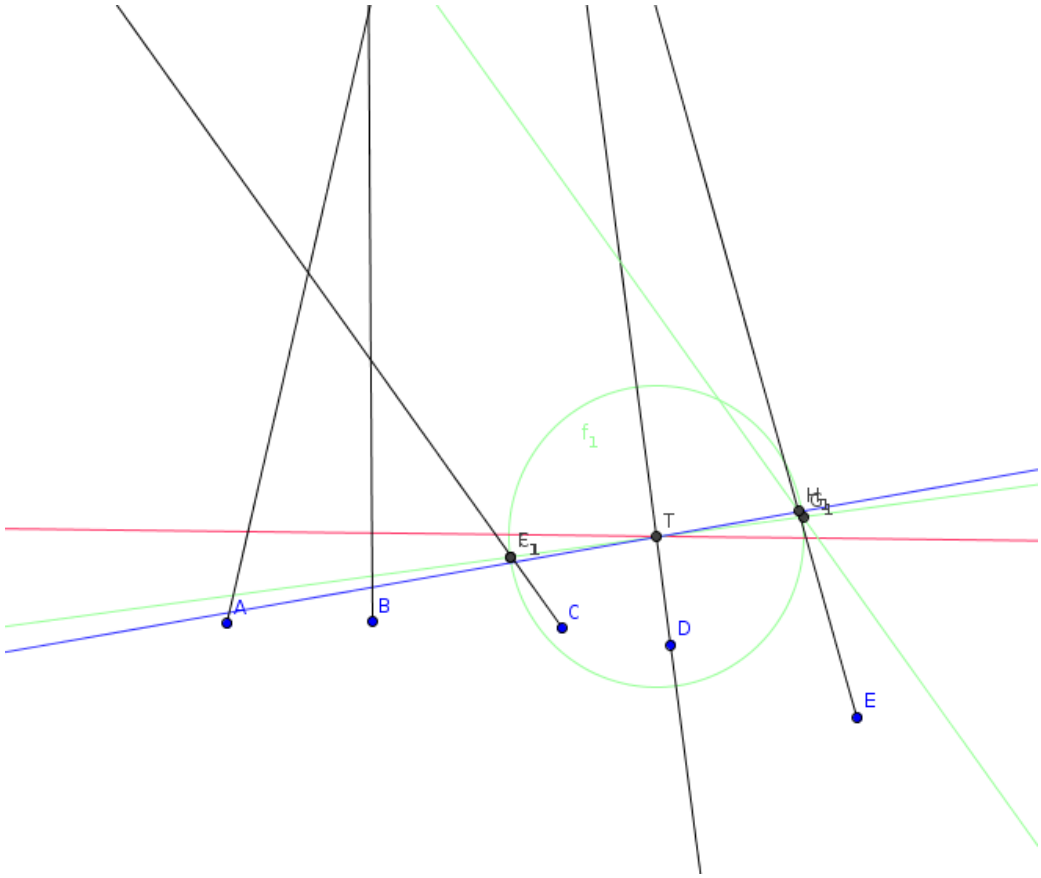
There is an infinite number of solutions for any given three bearings. With a fourth one we can fix position and therefore course and speed of target. In order to do that, we will protract the distance between *P2/Q2* and *P3/Q3* along both solution courses, which gives us *Sp* and *Sq* :



The good news is that any other solution will lie in the same line (yes I can prove it), in red above, so after drawing it, a fourth bearing will give us the true position of the target T:



We still don't know speed or course, There is enough information to obtain both but the easiest way to deduce them is to take a fifth bearing (from E) and repeat the procedure with the last three bearings through *T*:



The course thus obtained (in blue above) is the true course of the target and now you can assess speed too. You are done. You know speed, course and position of your target. Time to manoeuvre accordingly and let your fishes go.