<table>
<tr><th>#</th><th>Question</th><th>Answer(s)</th></tr>
<tr><td>1</td><td>is the redo up yet?</td><td>live answered</td></tr>
<tr><td>2</td><td>How the satellites know where they are again?</td><td>We have some reference sites on the ground that are well calibrated that we assume are "exact". Then the GPS satellites know their location relative to those sites.</td></tr>
<tr><td>3</td><td>Why can't they be co-linear? I'm drawing out a few examples, and they still intersect at a unique intersection.</td><td>We only know the distance from each satellite, so if they are colinear, multiple solutions satisfy the problem.</td></tr>
<tr><td>4</td><td>is our song 4 samples long and on replay?</td><td>yes</td></tr>
<tr><td>5</td><td>I'm still a bit confused about sample. I remember last time we had to convert time from sample to seconds when doing distance calculations?</td><td>Yes, when we want to calculate the distance, we need to convert the time to seconds. When we just talk about the signal, we typically label the time stamp by 0, 1, 2, ... The time delay in seconds will be the time delay in integer number times the time stamp interval in seconds.</td></tr>
<tr><td>6</td><td>It seems like the received signal is nondeterministic. 2, 6, & 10 would all appear as the same shift, so how would we distinguish between them?</td><td>Its still completely deterministic, based on your distance to the satellite. You are right that they all are possible solutions. We try to avoid this by making the song very long.</td></tr>
<tr><td>7</td><td>how can we know that the delay is 2 samples not 2+4 samples ?</td><td>Good question. In general, we design the song to be very long so that the likelihood of looping is low.</td></tr>
<tr><td>8</td><td>How do we get our received signal? For this example, how do we know it is delayed by 2 samples</td><td>live answered</td></tr>
<tr><td>9</td><td>What do the numbers in s represent, again?</td><td>live answered</td></tr>
<tr><td>10</td><td>if the sample was delayed 6 seconds, we will have the same r vector, will this effect the calculation of the distance?</td><td>Yes that's correct. In practical systems we will make the 'song' very long so we don't have this ambiguity issue for any practical distances.</td></tr>
<tr><td>11</td><td>Is it fair to assume that this process is only reliable when the time it takes to reach the destination is less than the time of the song?</td><td>Its not the *only* qualifier of reliability, but its a very useful property that we will assume most of the time.</td></tr>
<tr><td>12</td><td>What about the signal are we measuring? Is it the amplitude?</td><td>Yes it's the amplituide</td></tr>
<tr><td>13</td><td>Do we shift to the right or left?</td><td>We shift to the time-delay side (right side on the time-axis). If the transmitted signal is at time stamp 0, the received signal will be at a later (larger) time stamp.</td></tr>
<tr><td>14</td><td>how do we know if t = 2 if it could also equal 6 and have the same vector</td><td>Generally, we just make our song very long (much longer than 4) so that this ambiguity doesn't happen.</td></tr>
<tr><td>15</td><td>How does the signal deal with interference? Like what if there was something in the way of signal before it reaches the target?</td><td>live answered</td></tr>
<tr><td>16</td><td>did we cross out s4 because it’s the same as s0 so we’d use s0 instead?</td><td>yes</td></tr>
<tr><td>17</td><td>sorry this just popped in my head, can midterms clobber the final?</td><td>Check piazza and the course policies</td></tr>
<tr><td>18</td><td>How do we know s0, s1, etc. given that they are shifts of the signal, and we don’t actually know what the original signal is?</td><td>We know the original signal, that's defined and stored in both the GPS satellites and our receivers.</td></tr>
<tr><td>19</td><td>Why is minimizing the difference equivalent to maximizing the inner product?</td><td>||r-s||^2 = ||r||^2 + ||s||^2 - 2<r,s>, the squared terms does not depend on the time delay, so they can be considered constants. Maximizing <r,s> will be the same as minimizing ||r-s||^2.</td></tr>
<tr><td>20</td><td>Is the dimension of the vectors r & s equivalent to the number of "notes" in the song?</td><td>yes</td></tr>
<tr><td>21</td><td>why is minimizing |r-s| equivalent to maximizing the inner product of r and s?</td><td>||r-s||^2 = ||r||^2 + ||s||^2 - 2<r,s>, the squared terms does not depend on the time delay, so they can be considered constants. Maximizing <r,s> will be the same as minimizing ||r-s||^2.</td></tr>
<tr><td>22</td><td>Why do we try to maximize inner product between r and every shift vector instead of just completing the norm (squaring and then square rooting) for every difference between r and a shift vector</td><td>Those will effectively be the same</td></tr>
<tr><td>23</td><td>I’m having a hard time understanding how the inner product tells us anything about the relationship of s and r, like how does it signify that they are closely related</td><td>||r-s||^2 = ||r||^2 + ||s||^2 - 2<r,s>, the squared terms do not depend on the time delay, so they can be considered constants. Maximizing <r,s> will be the same as minimizing ||r-s||^2, which tells us how close s and r are.</td></tr>
<tr><td>24</td><td>how do we go from the product of values of volume in the vector to the geometric representation? Is there an intuitive way to see how those two ways of calculating the inner product are equivalent?</td><td>I don't have a quick answer for this, but you can probably find something in the context of vector projections.</td></tr>
<tr><td>25</td><td>Why is <x, x> >= 0 and not just equal to 0</td><td>The inner product of a vector with itself is equal to the magnitude squared. So this says that vector magnitude >= 0.</td></tr>
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26	what was property two saying again, I don't quite understand it with the vector notation	I missed if it was addition or scalar multiplication, but ... <x + y, z> = <x, z> + <y, z> states that if we add 2 vectors and take the inner product, its the same as taking 2 separate inner products and adding them. <ax, y> = a<x, y> states that scaling a vector and taking the inner product is the same as scaling the inner product
27	why wouldn't the inner product be minimized when the vectors are aligned exactly opposite (cos(180) = -1)?	Yes that's correct if we keep the lengths of the vectors constant and only vary the angle.
28	will the received signal always be a shifted form of the transmitted signal by n samples? also, would we have to convert the received signal to the nearest integer?	We assume it's always an integer number.
29	why does k to go infinity and not the length of r or s?	In the definition we don't know the lengths of r and s (we assume we have infinite length with repeating patterns). If we have finite length like length = 4 samples in our example, we will just fill all other samples with 0.
30	If we didn't receive a signal would that place be 0?	yes!
31	What do we do when s is not drawn?	We use 0 for those samples
32	where did r(0) and r(1) go	They are zeros
33	Shouldn't we extend t since it is a continuous signal?	Here we assume we only have 4 nonzero samples in s and r.
34	i dont quite understand how we got the graph for vector r based off of the values of vector r	r is a shift of s. The four values in the vectors represents the case when the signal is repeating. It does not directly match the graph. Don't worry too much of the vector numbers in this example.
35	why do we always start from r(2)?	r(0) and r(1) are zeros
36	why do we start at 2 here as well?	r(0) and r(1) are zeros
37	So, why aren't we taking r(3)?	we do have r(3) in each calculations
38	For Corr(s)[1], how did we get the value of s(3) to be 3?	oops, that probably should be 1
39	is r4 supposed to be there twice?	oops, the 2nd one should be r(5)
40	How are cross-correlation and inner product related ?	yes, cross-correlation is just a bunch of inner products with shifted versions of the signal
41	when do we know to stop multiplying? when we reach the end of r? which is r(5)?	yes. We assume that beyond the ends of the signal is 0.
42	can your song be too long	yes, but it would be for practical reasons, not fundamental / physical reasons.
43	For the song, why not make it start at a really high value and have it strictly decreasing to 0 for the duration of the song? This way, finding the correlation doesn't require you to compute an entire inner product, and you could instead find the closest value for any point?	Yes that's a good idea for ideal cases. In practical systems we have to take the noise effects into account. Noise will vary the level of signal we receive, and probably make the closest value finding procedure problematic.
44	Could you start repeating values at a point where you assume there is a maximum distance/ max delay that could be reached (ie no way to have object further than the largest diameter of earth or smthg similar)?	Yes you could. That's a good point, and a good thought about how to design / choose GPS "songs".
45	I think I missed it, but why are we only using 1s and -1s here? Is it just for simplicity of math? Design-wise, it would be better to have more varied numbers right?	Digital values are typically more robust (less vulnerable to noises), and GPS signals do not need to include a lot of other information (we don't need to send pictures or videos via GPS). But yes we can use other numbers to include more information, for example in wifi or LTE we definitely want to transfer a huge amount of information in a short time.
46	the error equations have the wrong signs, right?	yes the signs should be flipped, but we care mainly about the magnitude
47	the || || indicate what again? like the ones around r and s	The norm (magnitude) of the vector
48	So is Si = Sa - Sb?	i is an index. It can be either a or b
49	if the satellites didn't have the same norm does we would just have an extra variable to take into account right, it wouldn't change our approach very much?	overall, yes our approach would be the same. having different norms does make some of the later comparison math annoying, so we try to make them the same.
50	Why doesn't the 2 matter?	If we are trying to minimize [-2 <s, r>], that's the same as minimize [-<s, r>]. the 2 is just a constant, we can't control it.
51	what if the correlation was -4.5 does that matter since the magnitude is higher?	That's tricky, but for the most part, we want positive correlation
52	Do S_a and S_b have to be picked such that their inner product is small for all the possible shifts?	yes!
53	Are Sa and Sb assumedly orthogonal?	We will design them so that they are as close to orthogonal as possible