

**Sue Nelson**

Hello, I'm Sue Nelson and welcome to the Create the Future podcast, brought to you by the Queen Elizabeth Prize for Engineering. Celebrating engineering visionaries and inspiring creative minds.

[Music]

Dr Gladys West is a mathematician who grew up on her parent's farm in rural Virginia in the United States. It was a humble beginning considering that decades later, her mathematical modelling of the earth's surface paved the way for the 2019 Queen Elizabeth Prize winning engineering invention, the Global Positioning System. During an extraordinary career, which encompasses teaching and working for the US military, Gladys was a pioneer in the use of complex maths and efficient programming that enabled many engineers to flourish. She also took part in an award-winning astronomical study that proved during the early 1960s. The regularity of Pluto's motion relative to Neptune. Earlier this year, Gladys became the first woman to receive the Prince Philip medal, the Royal Academy of Engineering's highest individual award. Gladys has a degree and Master's in mathematics, a second Master's in Public Administration. And she embarked on a PhD in public administration and policy on retiring at the age of 68. A stroke interrupted her progress, but she carried on after recovering and was awarded her degree, aged 70. Now 90, Gladys is enjoying her legacy and her grandchildren. And I'm delighted to have her join us today, beginning by explaining her mathematical contribution to GPS.

**Gladys West**

I got a job using the computers that were being developed at that time in my life. And we were so excited and happy because they were so big and they could process so much data at a high speed, so that the math and the computers and GPS all would have gone hand in hand together, as far as the solution and being valuable. So even though I wasn't aware, not to certain extent of what I was really producing, as a final product, I didn't know that I was using math and I was using geodesy, and all, but just excited because we came up with GPS.

**Sue Nelson**

Modelling the Earth's surface, why do we need to model the Earth's surface?

**Gladys West**

Because we didn't really know what it looked like, how we acted were the forces on it, we just didn't know enough about it. To write up a set of intelligent equations for solutions. That just was a part of the problem that they were trying to solve at that time. And everybody knew about the problems. But this was the first time they had a computer and all that was big enough to handle all the databases and satellite recording every time it goes around the earth and bunkers full of tapes of a satellite data. I mean, we never had anything that exciting before.

**Sue Nelson**

Yeah, you said it was exciting. How long did it take you to write a programme that would do this sort of work?

**Gladys West**

It was done in stages by many people. I haven't counted them. But I can imagine over the time, it was a few years to get all the all the work done. And we weren't the only organisation that was working on it either, we worked with DMA and NRL and other places too. So, it just wasn't a simple thing that one person gets to do for a week or two weeks or something like that.

**Sue Nelson**

So it's a real team effort?

**Gladys West**

Yes.

**Sue Nelson**

And when did you discover a love for maths because growing up on a farm, you wouldn't automatically assume that "Oh, and a mathematician is born"?

**Gladys West**

No. To tell you the truth. I didn't ever really discover the love for math. What happened was when it was getting around high school time, and you need to make up your mind about what you're going to major in and what you're gonna strive for when you get to college, my teachers, I guess had more influence in that area, because they felt that I was doing all of my courses very well and I had no problem with my courses. So, they felt that as advice that I should take one of the areas that I was good in, and it was more difficult. And it provided more of a variety of jobs and all rather than taking something that's easy to, have fun, I guess.

**Sue Nelson**

So your teachers saw your potential there? Were your parents slightly disappointed that you didn't want to work at their farm, or were they supportive that you were going off to do something different?

**Gladys West**

I don't think that they were disappointed, I think they were happy that I was still striving to do better and to eventually be self-sufficient, you know, to take care of myself and to help them. I think they still saw me as a bright light shining for them. And I'm still striving and I'm doing all right. I didn't step down below. I still was stepping up.

**Sue Nelson**

And did they have a college education? Had they gone to university?

**Gladys West**

No, that that was the sad part about it, I guess. But my mother was smart as she could be. She could read and write it. She didn't finish elementary school, I don't think. But during that time, schooling was very different. And we didn't even have buses to high schools and all that. So they didn't have the opportunity to go further than where they could walk to school. But she was smart enough to know that she wanted me to do better be better. To be what she couldn't be. She knew she was bright. And she mentioned to me one day, that when school opened and she couldn't go to school, she just cried all day, because some of her friends went and she couldn't go. So, she was geared in, she made me even more aware of the necessity of me going to school.

**Sue Nelson**

It does bring out a bit of a determined streak in you doesn't it, the desire to do them proud?

**Gladys West**

Yes, it made me know that I had to win. I just couldn't be a failure, I had to win. I would have disappointed so many in the family. And myself. I couldn't imagine myself being married with two, three little children standing, waiting for me.

**Sue Nelson**

Now, your parents couldn't afford a college education, but you got a scholarship to Virginia State College, which was a university which only took people of colour and this was during the late 40s and early 50s. Did you ever feel lonely, the fact that there were so few women studying maths at that time? Or did you feel at home?

**Gladys West**

No, I didn't feel lonely, but the classes were small. So as long as I had one or two friends, I guess I was never excited by having a lot of friends. So that sort of suited my personality in a way. And we all were black at the college also. So, there was no integration. Separation would have been in terms of being with the educated professors and people who had education. That will would have been the separator if there had been something, but the kids were they were just having a good time.

**Sue Nelson**

And you had to pay your way through college and do jobs, didn't you?

**Gladys West**

Yes, the scholarship paid all my tuition. But then I needed some other fees, room and board and whatever. At the end of the first year, I had gotten a job that allowed me to work at a professor's house for the rest of the money that I needed. So after the first year, I had no problems in money any more because, you had to study to make C average, at least with the scholarship to keep the scholarship and I knew then I was gonna make that C average. I was working, working hard. And I always feel like a result of that was I didn't get to play as much because I knew that I was serious about never going back. And in order to do that I would have to work to make sure of that. We came from a country High School, also, which means that we weren't quite as prepared as kids were from bigger High Schools.

**Sue Nelson**

And after your degree in maths, did you decide to do a master's immediately?

**Gladys West**

No, after got the degree, I taught for two years in a high school, I taught math and science. But I think I mentioned I lived, with some professors, the math professor and a physics professor, I met with them, I lived with them. And they were trying to tell me that the first job I shouldn't worry too much about. Because I should use it as a stepping stone, I could use it as a stepping stone to something that was more closer to what I wanted, I guess. And so I took that advice. And I took the first job that was offered me, which was a teaching job in Waverly, Virginia. And I taught math and science. And I stayed there for about two years and I thought that felt about right. So I resigned and went back to Virginia State to get a masters and got a masters. Then at the moment, I came out with a few other things that happened. I got hired at Dahlgren Virginia. And that's where I sort of stayed.

**Sue Nelson**

And this was the US Naval Weapons laboratory?

**Gladys West**

Yes.

**Sue Nelson**

So you were a programmer and a mathematician there, what sort of work did you have to do? I suppose it being a weapons laboratory, there's only so much you can tell me.

**Gladys West**

What we would have to do would be to learn the equations, the theory and all of the problem that you're working on. And then they taught us how to lay out the design, they call it programming, I would lay out the logic to go through to get you to the answer, you have to lay that out. And then they'll, in order to talk to the

machine, you had to learn a language to say things that it recognised. So that's called coding. So, we learned how to lay out these programmes, had them outlined in your head, you could be walking around, you could be still working on your work. It was new for us too, because we, to tell you the truth, we didn't know anything about computers before we came. And nothing we didn't even have a computer at our school before. So that means it was a long, sort of climbing up the hill to get on board. But it was exciting. And everybody else was excited about all the capability that we had. And so you didn't take any chances of not doing your best. So we did our best to get aboard and be able to programme in code.

**Sue Nelson**

It sounds like you've really enjoyed it. How did you end up working on an astronomical study relating to Pluto and Neptune? That seems a sort of, wow!

**Gladys West**

Yeah. But you know, if you knew the kind of organisation it was, and that's what they were working on, you tend to say this other way, that you are assigned to projects that are available at that time. And so, I guess I just happened to be ready for a new job. And I got to work on this Neptune and Pluto thing. The men who sort of designed it for us too, they were more senior people and I guess, they probably wanted to give us some kind of experience and stuff, too. So, they sort of put new people with more seasoned people.

**Sue Nelson**

Now, you know, we sort of touched on some of the race issues, because you were working for the government did that mean you couldn't take part in any civil rights protests at the time?

**Gladys West**

Well, that's what we understood that we could not do that. So, we were unhappy in the sense that, you know, we could walk by the stores and Fredericksburg and we could see people sitting at the counters and all and we don't know whether we should walk by and go another way or something because we don't know how they'd feel about us. So we decided that we could help by just being us in being the best us that we could be and respect them and respect yourself what you're doing. But always, you know, like being favourable in a favourable sense, you don't know negative and get in the fight for something you don't know quite what you're getting in for.

**Sue Nelson**

Now, during the mid 70s, and throughout the 80s. This is when you were working on using algorithms to account for these variation in forces that distort the Earth's shape. And that's quite interesting, because it wasn't that long ago when I discovered that, you know, the Earth is not a perfect sphere, but it is a sort of wobbly, odd shaped sort of globe. So what sort of forces were you examining.

**Gladys West**

There's a variety of forces, you know, the gravitational force in the shape. And the big clumps here and there cause things to happen different and in tides, the water goes in and comes out and all that. So, we had special scientists who worked in particular force areas to make sure that we were understanding and getting it just right. And they all total up to one big force that causes the earth to wobble or not wobble.

**Sue Nelson**

And I read that you used an IBM 7030 Stretch computer?

**Gladys West**

I'm not sure why they gave it the name Stretch, but we liked it. It was an improvement over what we knew when we started. We had the NORC (Naval Research Ordinance Calculator) we had that. And then we got the stretch after that. Maybe that was a stretch.

**Sue Nelson**

And where these the size of a house type computers.

**Gladys West**

Yeah, these were computers that occupied rooms. We didn't go down to the next level unless they called you down there. You didn't get in the way of the computers and the men who. We had a group of people who maintained the computers and kept everything safe and analysed it, did all troubleshooting. It was a big operation because it was new. And now I guess we have a little computer on our wrist that can do as much as those big computers can do. One thing about the Stretch and all those, they were big, they could process more data. They could do forces and all but we were still using machine language. It was, I guess at the bare minimum, you're using pluses and ones which made it more difficult to programme and code for it. But as the Stretch came, we made a language. And it wasn't Fortran. This one was a step below Fortran, it was an improvement on the very first one we had.

**Sue Nelson**

You're write it was called Stretch because it stretched the known limits in computers. And at the time, it was the fastest computer in the world for a period of time and in the 60s. So, you were working right at the forefront of computing.

**Gladys West**

Yes we were.

**Sue Nelson**

And you know, your work modelling the earth has paved the way for GPS. And this is, you know, hugely significant technology used all over the world by so many people every day. Do you think people realise how important mathematics is for engineers?

**Gladys West**

Yeah, math is a powerful method of doing things. Just understanding the math can apply to other thoughts, other discoveries or other ways of looking at things, if you've got these equations that need to be inverted, you have to set up this humongous list of data which represent each one of the forces and all you have to invert that. And you have to have in your mind, what is this that I'm handling, and being able to just follow that thinking while you're doing something else, that then may be a little different than what you think you're working on. It's mind boggling in a way, but as you learn it becomes just a part of your way of thinking when we're like this, when you're working with math. And math is always I feel so clean, and logical and precise, and has a lot of advantages to using the math and engineers, a lot of times use a lot of equations and all that does write out math.

**Sue Nelson**

What made you decide to study for a PhD after retiring?

**Gladys West**

I have to tell you truth, that I was studying for many years before then. I never gave up and never stopped studying, I always would look at my schedule and determine what it was that I could do at this time, or what

kind of free time that I had, or what was the most important thing me do next. And so I was always taking some kind, of course and some kind of this. And then after you get to a certain point, you feel like if you want to come to an end, or you decide what you're gonna do, what kind of degree you're going to get if you go ahead and apply that, apply that rather than just studying. So, I had done all my coursework before I retired, and also gotten my title for my thesis approved, I had got all the little things need to be swept up, cleaned up good. I got all that done before I retired so that I didn't have to go back and worry about the government.

**Sue Nelson**

And are you still learning today?

**Gladys West**

I like to say no. We're having a hard time with these computers now.

**Sue Nelson**

And looking back on your life, when so much has changed within science, technology, engineering and maths since you started your career. What progress do you think is left to be made?

**Gladys West**

Oh, dear, I think there's so much that I couldn't even comprehend how it is because these computers today are just so powerful. People understand so much, things are so fast, and everybody's getting used to it becoming a way of life, they way you have to think. There's so much you can learn and be more prepared. If you want to get into like going to the moon and you know having a seat and coming back home. It's just powerful. It's so much I can hardly imagine.

**Sue Nelson**

Yeah, the possibilities are endless.

**Gladys West**

Yeah, it's just mind boggling.

**Sue Nelson**

What do you look at as the highlight of your career?

**Gladys West**

You know, I keep changing my mind about the highlight. Sometimes I think one way, another time I think others. I would think first, when I got that college degree that I knew that I was ready. But then when I started on the studying to continue on with my life, I feel like I wasn't so ready. And now I'm just thankful for being able to see the recognition that other people are giving me and how much I have affected other people. And to me, that is a big thing for me to see too. Because it's it's hard to figure out exactly what you're striving for what you're trying to get out of this, which you know, is something that you're working on.

**Sue Nelson**

As a mathematician, how do you feel about being a role model within engineering?

**Gladys West**

I think my role modelling would be such that I didn't give up, I strive to get what was necessary to proceed. I got help from other people, for example, to be hired for the job for college and also getting a scholarship. I feel like the role model, a lot has to do with applying yourself and working hard as you can and taking advantages that

are available and believe in yourself. Even though you're struggling, you know, you're down below, you still have to struggle. Even though you're mathematician or your an engineer, I don't think it makes that much difference if you got the thing that make you strive for what it is that you need at that time.

**Sue Nelson**

Do you use GPS yourself?

**Gladys West**

I would say yes. But I don't drive as much now, as I did before. So I'm only using it when my husband or son-in-law or somebody takes me somewhere. I use the same one that they're using on their car. But it is fun when you're using it and you're driving. But I always said that I like see more and know more than what they tell me to turn right, turn left, in two miles turn this and that, when I get through at the end of all those pieces.

**Sue Nelson**

And congratulations by the way on the Prince Philip Medal.

**Gladys West**

Oh yeah, I thought that was great, too.

**Sue Nelson**

Yeah, I was gonna ask you how you how you felt about getting that award?

**Gladys West**

I was real proud. I guess I was proud of that one because it was in another country. I had been there to the country. And I knew a little bit about it. So, I was really pleased with that. And I got to talk to her when she gave it to me. Princess Anne.

**Sue Nelson**

What an honour and What an honour it is to have you on the Create the Future Podcast, Dr Gladys West. Thank you so much for joining me.

**Gladys West**

Yeah, thank you. Thank you for having me.

**Sue Nelson**

Find out more about the Queen Elizabeth Prize for Engineering by following @qeprize on Twitter and Instagram, or visit [qeprize.org](http://qeprize.org). Thanks for listening, do join me again next time.