Commencement Speech

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Good morning! It's a great pleasure to be here.

I think in keeping with the fact that education is a lifelong activity and that very few of you have attended classes this morning, I thougnt I'd start with a math example. People laugh when they're nervous and math makes many people nervous, I'm ashamed to say. Ashamed because my half of the world, the techy half, has not really gotten our story out to the rest of the folks. And that's what I want to talk about this morning.

But you know, no matter how much you study we hear that computers are getting twice as fast every year. Or if you read something in the paper, someone's got a computer that's some enormous size, a huge brain and everything else. I just wonder, or somebody must, I just wonder, why bother getting educated at all. Why bother going to all this trouble writing a book, when after all, you just get enough computers, get them to type away at random and pick the one you like best.

There was a while ago, some years ago in fact, before computers, this particular story was told in slightly different terms (They didn't have computers; they used monkeys.) They said if you had enough monkeys, put them on the moon and gave each one a typewriter, they could type the Encyclopaedia Britannica. I don't think any of you want the Encyclopaedia Britannica but it would help if one of them would get your term paper. So I thought I would address that subject with you this morning in a math lesson because I think it's a very important math lesson.

The biggest computer I know anything about can handle several million instructions in a single second. Now in a second of several million instructions is far more than I can do with pencil and paper. Adding two numbers or multiplying two numbers, that's what instruction is, an operation. Well, people get supercomputers of a few million, soon they'll be to a billion, a billion instructions per second. I'm sure some people are approaching that enormous number. A billion computer instructions, by the way, could do all the math homework assigned in high schools and public schools in this country in any one night in pre-calculator days. Nowadays, with calculators kids get some help. But a billion instructions could do all the math homework in the country. That's a lot of computing.

So let's go a little bit faster. I think in a few years, by the time you folks are ready to stand up here and give commencement addresses, it might be conceivable that a computer could be working at a 100 billion instructions per second. Now a 100 billion instructions per second is equal to all the computing power that all the corporations in the Fortune 500 have on their desks, have in their labs and being ordered and designed today. Counting personnel, data keeping, all the computers in the country today essentially can do 100 billion instructions per second.

So let's assume then that everything is shrinking, everything is getting smaller. You get computers on a chip. They come in greeting cards nowadays. You get computers so small on a piece of silicon that people throw it away in a greeting card. A friend of mine had one such greeting card. It came to his house. It didn't say anything when it arrived. He put it on his mantel with his other cards. Then, a couple of days after Christmas he put it in his trash. And still nothing happened. A little while later he put some grapefruit rinds in there and some other stuff, and all of a sudden his garbage started playing "Jingle Bells."

Computers are everywhere and they are getting bigger and more powerful. So, think of that--100 billion instructions. Now let's see, let's see how hard it would be for a computer to do something for us, to get a real sentence. And when you're typing, what does everybody type? What does everybody type? I don't know what you folks type today but when I was a kid and got my hands on my first typewriter, it was "Now is the time for all good men to come to the aid of their party." Now that's 68 characters, keep that in mind, 68 characters on a keyboard.

Well, 68 characters, let's see how hard it is for this 100 billion instruction computer. Anybody want to take a guess? For a 100 billion instruction computer to type that single sentence correctlyly at random? Has anybody have the guts to have a guess? Would anybody who thinks it's less than a week raise their hands? Less than a week. Anybody in the audience who thinks it would be more than a century? Five people, six, seven. Seven people think it would be more than a century.

Well, I got my Nobel prize (I can now say that without stammering. It took a few years to say those words together but I'm getting comfortable with it) Right now, from what we can gather from the flight of the galaxies--we look at galaxies, we see them all moving away--and just in the same way that if you know a truck is 30 miles away and is traveling at 15 miles an hour, by taking the speed and distance of the truck you would know when the truck was next to you. The same way, we do exactly that same calculation with galaxies, and instead of the 2 hours you would get with the 30 miles and 15 mile per hour, we happen to get 18 billion years. Well, 18 billion years is a pretty long time. And we can convert that into seconds if you want. It turns out that since the beginning of the universe, just to get a single number, we've had a 100 quadrillion seconds. That is 10--the figure 1 with 17 zeros after it. Now our computer worked at 100 billion instructions per second. That's 10--1 with 11 zeros.

Now let's get a lot of these computers. How many computers could we get in the entire world. Well, I don't think the number of computers in the world, no matter what you do, is ever going to exceed the number of atoms. Think. Well, how many atoms are there in the world. You can do that calculation. A man named Edington did that calculation in the 1920s for the first time. And it turns out, I don't know, I could probably figure out for you if I spent the time to go for millions, billions, quadrillions, quintillions, etc. what it is. But I won't try. But the number happens to be a 1 with 88 zero seconds after it, eight zero, I'm sorry, a 1 with 80 eight zero zero eight zero zeroes after it. O.K.? If we multiply numbers we add zeros. Ten to the 11th, 100 billion instructions per second; ten to the 17th, 100 quadrillion seconds since the universe started; and ten to the 80th computers working at the same time. That's ten to the 106th.

Ten to the 106th. And all we have to do is type 68 characters correctly. Well for each character you've got about 100 choices. You've got upper and lower keys, upper and lower case keys as well as about, in total about 50 keys. So that's about 100. So every time you hit that keyboard or anytime the computer selects a charactergram it's got a 100 choices. Well, 100 random choice taken 68 times (for those of you that play crap or bet on the daily doubles, you know that these things multiply. Right? If you've got a chance of flipping a coin, you've got an even chance, one chance in two of getting a head when you flip a coin once. One chance in four of flipping two heads in a row; multiply two times two.) Well, if we multiply those 68 characters by 100 we get a number 10 with 136 zeros after it. Right? That's 68 squared, 136. 136 zeros. So we failed. All these computers, 100 billion instructions per second computers working since the beginning of time, one of them for every atom in the universe. And we failed by a million, billion, trillion times to do that one single sentence.

That tells you something about blind movement, blind operation, brute force approach to the world. It tells you where the machine is compared to where you mind is. Sure machines are getting more powerful. But there's a tremendous difference between mind and machine. Computers can do some pretty good things, pretty impressive things, when one narrows the field. When one narrows the field, say in the case of playing chess. Chess is a very narrow game. You only have 16 pieces on each side. You can only move on a chess board. And chess-playing computers have been invented which, in fact, go through some of these what I call, the example I gave you previously is what I would call an exaustive search, for the right answer. Computers do exaustive searches and they have some clever smarts so they don't blunder badly.

In fact, at Bell Labs we built such a machine. The people who did it named the machine Belle. B-E-L-L-E. And Belle was the queen of the chess board for many years. Belle was the first computer ever to be granted masters rating by the International

Chess Federation. Belle could beat 99% of all the serious chess players in the world. But it didn't beat one high school student in the state of Pennsylvania. One of the things Belle could do is it would play a lot of people. And so this chess club from Pennsylvania played Belle simultaneously. They could think while she ran the program. I don't like to anthropomorsize the machine but I make that exception in her case. Belle was playing all these people including the high school kid who was one of the worst players in the group. Only one person that day beat the machine. And that was the kid. He realized that in face-to-face orthodox chess he had no chance. So what he did was, he made a bunch of perfectly legal but bizarre moves hoping that those moves were not preordained or considered by the designers. And sure enough he hit it and Belle lost that one game. Everyone else in the club who were beaten by the computer could have beaten that young man. But what he did was, he used the human ability to change the rules of the game. The human ability to look for something else. Not the kind of brutal, brute force drive through approach that machines are forced to use. But some of the extra smarts that we as human beings are given by nature.

So technology, while it's very, very powerful, is a complement rather than a replacement to human beings. And as a complement for human beings, it has to become a complement for all human beings. Not just for the techy part of the world. I think people have to be able and willing to exercise their minds by asking questions of technology, all kinds of technology, with the expectation that they can understand it.

A friend of mine, one of the smartest people I ever knew, and a graduate of OSU some years ago, 1927 I believe, and a brilliant engineer in his own right, had a terrible time, had to force himself to overcome asking questions. He was sure that every time he asked a question everybody would realize how foolish and naive he was because all the other people around him were so much smarter. Because they didn't ask any questions, they must have known it already. And he went through life feeling very foolish even though he was the only one who every clarified things in a group. He was the one other people came to as a resource for information because he knew the stuff. The rest of them were too intimidated, too afraid.

And I hope you wont take that attitude. I tried to that with my children. I didn't totally succeed. It took my daughter 10 years to work up the courage to ask me how the rear view mirror in an automobile works. How many of you know how the rear view mirror works? Want to raise you hands? How many know what the scientific principal is? One, two, three, five, six--o.k. The rest of you have never been in a car, I guess. Well, she asked me one day. She said, "Dad, I can't stand it any more. I know I'm the only person in the world that doesn't know. But you gotta tell me. Why is it, when you flip it, you get a darker image? And even if you flip it up or flip it down, there are these dark images on both sides? And it's just a piece of glass with some silver on the other side. How can this mirror have more than one image? It doesn't have it on the mirrors I know about." And so I explained to her about defraction gratings - forming microscopic lines on the back of the mirror. And their order of difraction. You may see that effect if you go to the southwest and you see rainbows. Sometimes you see a second rainbow inside the first. And that's another difraction order.

And I gave a talk earlier this year at Southern Utah State College where I mentioned that example. And that did me a big favor, gave me a great insight, which I want to share with you. It turns out that, at this place, they take these lectures and they publish them. So I got a transcript back. First thing you try to do with such a thing is get rid of the spoken English and turn it into written English, for after all it' very hard to wave your hand on a piece of paper. And after I did it I sent it to a friend of mine. And he came back with a few words on it saying, "I don't think your explanation of the rear view mirror is right, Arno." So I got on the phone in the physics division of my organization, I started calling department heads till I find one in in the physics division. They're out--they're doing other things. They don't spend their times sitting in their offices waiting for a vice president to ask them a question. Well, anyway, I said, I asked her, "Jerry, do you know how a mirror works? I'm not sure." And she did. It turned out that what they do is, the company, real companies, have here a mirrored section, a mirrored metal surface and in front of it they put a wedge-shaped piece of glass. Now if I had four hands, I could take some light, most of the light goes through the glass, goes out to the mirror and come back. But a little bit of this light bounces off that wedge and goes the other direction. So when you turn it, when you turn that wedge, you get the second image. So I didn't know any better than she did.

But the only way I found out was finally, after decades of misunderstanding on my part, some non-scientist asked me.

Interllect and technology can't separate from each other. Technology is the application of organized knowledge, all kinds of organized knowledge. Now we can walk around this campus and there are the newer buildings but the traditional, the older ones, borrow their architecture from a group of people (if you think Columbus is a small place) from a group of people who were so few in number that the postal service would never have given them a zip code. Ancient Athens. Athenian architecture is so fantastic that 2000 years later people still copy it. Some Greek plays written at that time are still produced today. People study the philosophy of the time. I'm writing a book on information and I started reading what Plato had to say about ideas. Brilliant people who brought the heights of intellect to levels which were unheard of in the rest of the world. And unheard of for centuries thereafter. And they managed to do it without computers, they managed to do it without cars, without communications satellites. They managed to do it without all that technology.

But they did have something that we don't have--a plentiful supply of human slaves. For every citizen in Athens, every citizen in most of the states, in Ionia, there were more slaves than citizens. And it was the forced labor of these latter people that allowed the senior group to enjoy themselves. It was not that the senior group was incapable of creating machines. Some Greeks, a Greek astronomer was able to find the radius, to find the diameter, I'm sorry, to find the circumference of the earth. He got it right within about 100 miles---about 2200 years ago. So they could have built technology if they had put their minds to it. But technology was off there somewhere. It was yucky. I don't know what the Greek translation of "yucky" is but it was something somebody else did. And since these other human beings were down there in slavery, they were doing the work anyway so why bother.

Well, one of the reasons you might bother is you might invent something useful like the harness. A harness for an animal, for a horse, is a very subtle piece of technology. Until the harness was brought, the modern harness was brought from Asia in the 8th century, it was cheaper to feed a human being and have that human being carry a load than it was to have a horse, or a donkey, or an ox, pull that load. And supported by human slavery as it was, and because these people in Greece had to support themselves to keep themselve on top of whoever they were oppressing, the system finally disappeared. Then we had 1000 years of what we call the "Dark Ages."

Well, some here in this room today are supported by slaves as well. There are homeless out there. There are unemployed.

There are people who are sick, who are mentally ill. There are babies born to teenage mothers who have no prospect, or almost no prospect of a life. And to help them we have to raise the pie, we have to make things bigger, we have to make things better in this world. And that isn't something the techy people can do for the rest of you. It's something we all have to do together. Mind and machine means everybody's mind. The minds that you have brought to Ohio State over the last few years, minds which have been enriched with knowledge. And minds which are now part of the resource that the rest of us in this society are counting on to make this world better. To integrate what you know with what needs to be done. And you can't wait for the machine to do it anymore than you can wait for it to type that single dumb sentence I started with. It takes creativity. It takes understanding. It takes knowledge. It takes something a machine can never have--sensitivity.

Those are all things which are part of education and the uses of education. And so I wanted to share that thought with you this morning and I want to wish you very well in the coming years ahead. Thank you very much for listening.