



EXPLORE

UNDERSTAND

SUCCEED

PHYSICS!



WELCOME TO THE FASCINATING WORLD OF PHYSICS!

What if you could create the newest, fastest computer processor, or turn the gaming world upside down by creating an entirely new type of game system? What if you could discover the next planet or enable humans to travel to and live on other planets? What if you could create a communication device that when implanted in the human body would allow us to access electronic information, communicate remotely with others, and enjoy thousands of songs all without the use of a computer, phone, or MP3 player? It just might be possible to do these things in the future, and with an in depth understanding of physics and physics principles, you would have the foundation that would make creating these things a possibility for you.

But, what is physics?

Physics is the study of natural forces in the universe. By studying these forces, we can understand why and how things work the way they do. When we understand these phenomena, we can then use that knowledge to discover and create new things. Physics is also the foundation of other fields, like engineering, and without it we wouldn't have a lot of the technology we have today.

How does physics relate to you?

It's because of physics research and physics discoveries that we have the cool and exciting technologies that exist today. Innovations using physics allow our computers, MP3 players and cell phones to store more and more data while becoming smaller and smaller. Physicists, or those who work in physics fields, also work on problems that help society. They help doctors diagnose and treat illnesses like cancer, and find solutions for environmental problems such as discovering more efficient and cleaner energy supplies. They also study space, planets, stars, and other bodies in space to understand more about our physical existence.

These are only a few of the important and fulfilling ways that physicists contribute to the global body of knowledge. Physics is a field that can be used to explore many exciting phenomena, and its applications are vast. Almost any career you chose would benefit from your knowledge of physics and if you choose to learn more, perhaps one day you will be the one to discover something that changes the world!

read their stories

Take a journey through this brochure. You will meet 10 physicists who were once like you; trying to figure out what they wanted to do with their lives. You'll see how they cultivated a love for physics and how they chose to turn their passion for physics into careers that they enjoy. You'll also learn how to prepare and pay for a college education in physics if you think physics might be for you.



DID YOU KNOW...

Edward A. Bouchet (1852–1918) was the first African American to receive a Ph.D. from an American university in any subject, and it happened to be in physics. Bouchet went to Yale College (now Yale University) as an undergraduate and graduated in 1874 as the only Black student in the school. He then continued on to receive his doctorate degree in physics in 1876.

contents

Nadya Mason	2
Keivan Guadalupe Stassun	4
Marta Dark McNeese	5
Albin Gonzalez	7
Lynett Rock	8
Collin Joseph	9
Edward Thomas	10
Paul Markoff-Johnson	12
Kelle Cruz	13
Alejandro Rodriguez	15
Preparing for a Career in Physics	16
Paying for Education	18
Potential Earnings	20
Additional Resources	21

START EXPLORING ---->

meet Nadya

MATERIALS PHYSICS



“To me, physics really described the world in a way I wanted to understand it.”

Nadya Mason always knew she liked math and science. By the end of her freshman year in college she knew which scientific field she liked best—physics.

To me, physics really described the world in a way I wanted to understand it,” she said. Now an assistant professor at the University of Illinois at Urbana-Champaign, Nadya studies the electric properties of materials. Her research could help make computers and other electronic devices keep working no matter how small they get.



Nadya grew up in three cities—New York City, Washington, DC, and Houston—because her family moved to find better jobs and better places to live. Nadya lived with her mother, a lawyer, and attended private school from fourth grade on. Science and math weren't Nadya's

only loves—she was also a very good gymnast. From the ages of seven to 16 she practiced extensively, eventually becoming a member of the Junior National gymnastics team.

While Nadya was in high school, she got her first opportunity for summer hands-on scientific exploration. People from a program encouraging minorities and women in the sciences came to her school to talk about summer science internships. Nadya was interested, and wound up at a university biochemistry laboratory for the summer. It was a great experience for her.

“I had never done any experiments before, I didn't even know what a lab looked like really, so it was neat being with the professors and graduate students, hanging out with them and thinking about their research,” she said.

She decided biochemistry wasn't for her, but she loved experiments. She also enjoyed internships, and participated in several more over the next few summers, including after she became a student at Harvard University. After she'd experienced biochemistry, geophysics, biology, math, chemistry and physics through internships and classes, she chose physics. “It was always when I got to the physics part of a science class that I finally had the ‘a-ha!’ moment,” she said. She received a scholarship from the American Physical Society to help her study physics at Harvard.

After graduating with a bachelor's degree in physics, Nadya continued on to get a doctorate at Stanford University. A few years after that, she went to the University of Illinois.

One of the things Nadya researches currently is what happens to the properties of materials when you make objects, such as computers, very small. At some point in the shrinking down process, the computer parts get so small they don't behave the same way they did when they were larger. Her goal is to figure out, “when they get this small, what happens, how we can understand it, and how we can use it to make the next generation of computers and electrical devices,” she said.

For young people interested in science, Nadya recommends doing what she did—experiencing different kinds of science to see what you like, even if it isn't something you considered before.

“Keep an open mind and follow your interests,” she said.



Did You Know

That the 2007 Nobel Prize in Physics was awarded for the science behind the magnetic hard drives in computers, iPods, and other kinds of electronic devices? The two winners discovered a physical phenomenon, called giant magnetoresistance, that makes it possible to pack more and more information on small hard disks. Experts say this discovery helped make MP3 players possible!

meet Keivan

ASTROPHYSICS



“I thought if I couldn’t go up into space, I would choose a profession that allows me to look up at the stars...”

Keivan Guadalupe Stassun has always been fascinated with outer space. As a child, he wanted to become an astronaut so he could study space by traveling into it. As an adult, he found another way to study space—becoming an astrophysicist. “I thought if I couldn’t go up into space, I would choose a profession that allows me to look up at the stars and ask the same kind of questions,” he said. Now an assistant professor of astronomy at Vanderbilt University, Keivan uses his physics knowledge to learn more about the universe.

Keivan is the first in his family to finish high school, let alone go to college. His mother was born near Oaxaca, Mexico, and came to the United States a few weeks before his birth. She worked cleaning homes until she and Keivan’s stepfather married when Keivan was 8.

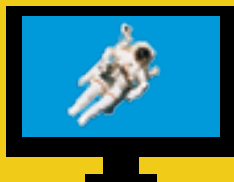
Keivan’s parents might not have had the educational background to help him with his classes, but they always told him “that my education was the most important thing,” he said. “There was an expectation that I achieve.”

Since becoming an astronaut was his original goal, through middle and high school Keivan took many intensive math and sciences courses to be prepared. But by the end of high school, he decided that his chances of becoming an astronaut and actually going up into space were slim. When he was offered a full scholarship to attend the University of California at

Berkeley, he accepted and began to study physics and astronomy. After graduating, he went to the University of Wisconsin to complete a Ph.D., and a few years later, he went to Vanderbilt.

As a researcher, Keivan uses what he has learned about the physics of light, such as how materials absorb and emit light, to try to answer some of the many unanswered questions about the universe. “All the information we have about the universe, with the exception of the moon and Mars—which people have actually visited or sent probes to—comes to us in the form of light that we receive from different parts of the universe,” Keivan said. “By using complex tools and equations, physicists can uncover information in the light that helps answer such big questions as where we come from and how the universe is evolving,” he added.

Keivan is very passionate about his work in physics and astronomy, but they aren’t the only things he is passionate about. As a professor, he’s involved in a number of programs to encourage more people of color to become scientists, including a program where he helps middle and high school students build their own telescopes. While he may not have become an astronaut, he’s helping others to realize their dreams, and that is a dream come true.



DID YOU KNOW...

That astronaut Mae Jamison was the first African American woman to travel in space in 1992 and astronaut Ellen Ochoa was the first Hispanic Woman to travel in space in 1993.



meet Marta

MATERIALS AND LASER PHYSICS

“I really wanted to...encourage young black women to go into the sciences.”

If physicist Marta Dark McNeese is successful, one day her research could be used to help injured athletes compete again.

Marta is using physics to develop a laser-based method to repair injuries in knee cartilage, commonly caused by sports injuries. She is also a professor at Spelman College, a historically black women's college.

Marta grew up in a suburb outside Washington, DC. She remembers being interested in math and the sciences as early as fifth grade. “I liked the idea that there was a process to learn and problems to solve in math and science, and I remember thinking of other topics, like history, as dates and things to memorize,” she said. Marta especially liked astronomy, and by the time she was 11 she had asked her parents for and received a telescope. She first realized she was interested in physics during a physical sciences class in eighth grade. She loved studying rocks, volcanoes and magnetic forces. She also liked that her instructor was an African-American woman, whom she could identify with.

Marta soon knew she wanted a career in science or math. With her parents' encouragement, she applied to a high school with a special science and math program and was accepted. While there, she took a number of different science classes, but found she didn't like biology because of the requirement for dissection, and since she had a fear of chemicals, chemistry was out. “So physics was the one for me,” she said.

After high school, Marta went to the University of Virginia. Within a few years at the school, she decided she wanted a degree in physics, and through a special summer program and class, she discovered she was fascinated with optics, the movement of light, and lasers.

After getting a bachelor's degree, Marta went to the Massachusetts Institute of Technology. It was there that she first began studying lasers and knee cartilage. Soon after she got her doctorate from MIT, Marta came to Spelman College, where she has been for the past



seven years. At Spelman, Marta continues her research on knee cartilage. She is trying to create a special protein-based glue with certain chemicals added to strengthen it. She would then use a laser to “weld” the glue to the damaged knee cartilage, repairing tears and strengthening the cartilage. She also has to figure out a way to keep the heat from the laser from damaging the cartilage.

Marta spends the rest of her time at Spelman teaching physics and astronomy classes, and helping students understand how fascinating physics can be. Spelman is “a wonderful environment for me and I really wanted to be there so I could encourage young black women to go into the sciences,” she said. Sometimes she presents science fiction movies in class to help her students better understand physics. Marta uses the movie Armageddon, and shows students “that the whole premise of the movie is flawed,” from a physicist's perspective. The approach is so popular that incoming students will often ask her if she plans to do it again.

But despite her best attempts, Marta sometimes sees students who don't understand why she finds physics fascinating. This is what she tells them: “You're really trying to understand how the universe works. What could be more exciting than that?”



Physics and medicine

If you've ever broken a bone, you've probably had an x-ray. There's another kind of more advanced medical technique based on x-rays, and it's something physicists continue to work to improve. Called a CT or CAT scan, it uses x-rays and a computer to take a picture of a person's internal organs. This helps doctors diagnose and treat diseases and better understand how the body works without surgery.

meet Albin

MEDICAL PHYSICS

“Right now in this field there are so many jobs out there...it’s really unbelievable.”



Albin Gonzalez first became interested in physics as a high school student in his native Panama. To Albin, many of his other classes were just about memorization, but physics was a challenging way to learn something new. Using physics, “you can describe the world that is around you through mathematical models and equations,” he said. “You can relate the whole world through the help of those equations.”

Now a medical physicist, Albin uses what he learned through studying physics to help people with cancer. Albin didn’t decide to become a medical physicist until he was in graduate school. The son of a butcher and an elementary school teacher, Albin was interested in both physics and economics as he finished high school. But when he started college in Panama, he decided to focus on physics. “I thought that physics has no boundaries,” he said.

Albin studied for a bachelor’s degree in physics in Mexico and Panama, and received his degree from the University of Panama. After finishing the degree he decided he wanted to get a Ph.D. in the United States, but only applied to one university because he didn’t have the money to pay for more applications. Luckily, the university, Vanderbilt University, accepted him, and he came to the United States in 1996. It was after a few years at Vanderbilt that Albin first thought about

medical physics. “I didn’t want to have to spend the rest of my life in the lab doing experiments,” he said “I wanted to do something where I could immediately help people.”

He approached a medical center and began studying there, learning how to use physics to solve medical problems involving radiation, which is used to treat patients with cancer. A few years after he finished his degree he began working full time as a medical physicist for a cancer center in Ohio. In his job, Albin makes sure that the machines that use radiation to treat people with cancer are working properly and delivering the correct dose. Through his studies in physics he understands how radiation interacts with matter, which includes human cells. He can model that interaction, calculate an appropriate dose, and with different detectors measure the dose a machine gives to make sure it’s the right amount. All this is very important in making sure that people with cancer live as long as possible or are even cured of the disease.

Albin loves what he does, and knows it was worth all the time he spent in school studying physics. “The way you are trying to think (through studying physics) is really unique—it gives you the ability to solve really difficult problems,” he said. He encourages other people to think about becoming medical physicists. “Right now in this field there are so many jobs out there,” he said. “It’s really unbelievable.”

DID YOU KNOW...



That the word “laser” is actually an acronym for **light amplification by stimulated emission of radiation**. Lasers are based on the fundamental behavior of atoms, and they’re used to read CDs and DVDs.



“I wanted to make sure that I represented my race and my gender to the best of my ability...”



Muskogee, Oklahoma, population 39,000, is in a rural area

between the Native American Cherokee and Creek nations. It is also Lynett Rock's home town. The area is so rural that when Lynett, a member of the Cherokee Nation, was a high school student in the nearby town of Warner, the school's physics class had to be beamed in via satellite from Oklahoma State University. Her graduating class had just 30 students.

As a high school senior, Lynett wasn't planning on a career in physics—she thought she'd be an accountant or a math major. But applying for, and receiving the American Physical Society scholarship for minority physics majors changed that. After taking her first university physics class, “It was obvious that this was what I was supposed to do,” she said, “Everybody has something that they get to be very good at, and physics just happens to be my area.” Lynett might not have found her calling until college, but she had long been fascinated with figuring out how things work. Her parents encouraged this, and made sure she had opportunities to satisfy her curiosity.

Although Muskogee is small, it is a very diverse place, says Lynett. However, her university science classes weren't. As a woman and a Native American, “I wasn't like anybody else, I was definitely different,” she said. But instead of feeling isolated and discouraged, Lynett said her uniqueness made her feel more determined to succeed. “I wanted to make sure that I represented my race and my gender to the best of my ability, and that I succeeded where so many others had not yet,” she said.

Through the APS scholarship she got additional help. The scholarship included funds to support physics study for the professor she worked with, and he made sure she was able to benefit from that. “He was always building something, and I got to be his helper,” Lynett said.

After getting a degree in engineering physics, Lynett continued on to graduate school, where she studied how electrons moved through glass with different properties. The goal of the project was to come up with the perfect glass for use on a counter in the space shuttle.

While in graduate school she didn't have any specific plans for her future. “I was so excited to be able to get my graduate degree, I hadn't thought much past that,” she said. But both her mother and her aunt were teachers, and as a high school student she'd enjoyed tutoring younger students. After getting her master's degree in physics, Lynett began teaching at a high school. When a position opened at a junior college in her home town Lynett took it, and she and her husband and children moved into the house next to her parents. She now teaches math and physics at the junior college and is the Division Chair of the Math and Science Department.

Lynett said that some of her students struggle with math, and she always tries to help them understand how important math is and how interesting it can be. Many of her students plan to become teachers, and she likes knowing she's helping new teachers become more prepared so they can educate the next generation. She also wants the next generation to realize it can do whatever it wants. Lynett said she's always telling her 12-year-old daughter, “There's nothing that anyone else has done that she can't do. But just because someone hasn't done it before, doesn't mean she shouldn't.”


meet Lynett

PHYSICS AND MATH PROFESSOR

meet Collin

PHYSICS STUDENT

“Physics is the science that addresses [how things work] most broadly and deeply.”



Collin Joseph remembers liking and doing well in all his classes when he was in elementary and middle school, but he especially enjoyed his math classes. “My family very much encouraged the sciences and math, so I was steered in that direction. But I was also very curious about what people understood about things,” says Collin.

Growing up in the Bronx, NY, Collin would “devour” popular books on science and math, and frequently picked up his father’s college level math textbooks trying to satisfy his intense curiosity. “I would read them, trying to understand what was in them, even though I was in seventh grade,” he said. By the time he actually began to study physical sciences in middle school, he’d been interested in learning more about physics for quite a while. That interest in physics hasn’t died—Collin is now a senior at Yale University, majoring in physics.

Collin says his teachers and parents were big influences on him while he was growing up. He recalls that when he was very young his teachers were good at explaining math and helping him learn. His father, a school psychologist, who once taught high school math in Antigua, would help Collin study math and sometimes give him more problems to improve his skills. Collin’s mother would check in with him to make sure he was learning and that his skills were progressing.

Collin’s parents had wanted him to become a doctor, something that he had also been interested in when he was younger. When Collin first decided that he wanted to study physics, neither of his parents was excited about the choice. But “once they started to see that I could still get recognition and that I was doing well at it,” they became happier with his decision, he said.

Collin knows he would like to go to graduate school and become a researcher, but he isn’t completely sure in which area of physics he wants to specialize. To help him decide, he spent the summer as an intern, studying how granular materials pack together. Sand is an example of a granular material. This research is important to society in a number of ways, including in making medicines. Many medicines are made of different powdered chemicals, and if physicists don’t understand how to keep them together, the powders could separate and make the dosage of the medicine incorrect. This can affect millions of people.

Although it might be a few more years before Collin knows exactly what he wants to study in physics, he knows he finds physics fascinating. He says he’s always been interested in how things work and “Physics is the science that addresses that most broadly and most deeply.”



DID YOU KNOW...

That all electronics like radios, stereo components, and even your microwave have all been developed based on research in quantum mechanics, a fundamental field of physics.

meet Edward

PLASMA PHYSICS

Edward Thomas, born and raised on St. Thomas in the U.S. Virgin Islands, has always been interested in science. But it wasn't until the summer before his freshman year in high school that he first had an idea of what kind of career he might want in science. Edward and his family spent that summer with Edward's uncle, a marine biologist, at a marine research institute, where Edward hung out with graduate students and postdoctoral students.

"I thought that was a really cool life," he said. Edward recalled that the students he met always made time to tell him about their work. "They were so enthusiastic and excited about what they did that they would spend hours talking to this 12-year-old kid," he said. "I had never met people who were so interested and excited about what it was they were doing."

Like the people he met that summer, Edward now lives a life focused on research. He is a professor of physics at Auburn University in Alabama.

After that summer Edward had an idea he might want to work in academia. By his sophomore year he knew he was interested in physics. He credits this interest to a very good teacher who taught him in several science classes. In physics class, the teacher would require students to work out problems on the board during class time.

"You really got a sense of whether you understood something or not if you could explain it to someone else," Edward said. Edward became so interested in physics that he changed his proposed major on his college applications from chemical engineering to physics.

Like many students in the Virgin Islands,

Edward came to the United States mainland for college. He attended the Florida Institute of Technology, where he received a bachelor's degree in physics. He then went on to get a master's degree in physics from the Massachusetts Institute of Technology, and a doctorate degree from the university where he is now a professor.



"I had never met people who were so interested and excited about what it was they were doing."

In addition to teaching university students, Edward conducts research. One of his areas of research is studying the behavior and motion of dusty plasmas. Examples of dusty plasmas include Saturn's rings and the tails of comets. But the application of Edward's work is something much closer to home—the production of microelectronics. Most microelectronics are produced using plasmas, and a byproduct of the production process is dust, Edward said. That dust is a big source of contamination, and people want to be able to move that dust to the place where they can get rid of it.

Edward's research and teaching work keep him busy. But he also finds time to talk with high school students, many of whom are surprised when he tells them how much time he spends writing and how important writing is to scientists.

"I point out to students, if you choose this career, not only do you have to be good at math and good at doing the science you're interested in, you have to be able to explain it to someone else," he said. To Edward, "Your writing skills are almost as critical as your math and scientific background."



Physics and plasmas

You've probably heard of solids, liquids and gases, but there's a fourth state of matter called plasmas. Plasmas are created when energy, such as heat, is added to a gas, making its atoms begin to lose electrons and become ionized. Some plasmas give off light. For example, fluorescent light bulbs give off the kind of light generated by plasmas. Plasma televisions are made of millions of tiny light emitting elements called pixels and each pixel contains a red, blue, and green cell that behaves like a tiny fluorescent light bulb. When an electrical current is sent through the gas in those cells, a plasma is created that then illuminates the cell. These illuminated colored cells, or mini lights, can produce all the colors in the spectrum and pictures on the screen. The more tiny lights you have, the crisper the picture!

meet Paul

MATERIALS PHYSICS

“Having an ability to explain the things I’m seeing around me with physics...was really exciting to me...”



Could you use physics to make an MP3 player hold more songs? How about generating electricity from the sun with something far thinner than a human hair? For Paul Markoff-Johnson, the answer to both these questions is yes. Paul has spent most of his career working on creating incredibly thin coatings made of materials selected for their special abilities. To get an idea of how thin these coatings are, imagine slicing a dime horizontally into a thousand slices. The coating would be as thin as just one of those slices!

The material Paul picks for a coating depends on what he wants the coating to do. For solar cells, he needs materials that generate electricity when the sun shines on them. In disk drives and disks, like those used in MP3 players, the coatings must have magnetic properties to create many tiny magnets inside the devices for storing huge amounts of information.

Paul knows which materials to pick for these coatings because of his studies in physics. He knew from childhood that he was interested in a career in science. He had always enjoyed math, but hadn't really understood how it could be practically applied until he took his first physics class in high school. He found the class fascinating.

“Suddenly having an ability to explain the things I’m seeing around me with physics, like why a car goes, was really exciting to me; to be able to put that down in numbers and equations,” he said.

Paul also appreciated his physics teacher, one of his favorite teachers in high school. “He wanted the class to be about learning the material and figuring out how things worked in the world, and not about competing for grades and trying to be the best of the best,” he said.

When Paul started college he thought he wanted to major in engineering. But after a few engineering courses, he decided he wanted to study something broader, and chose physics. Paul continued his studies and earned a master’s degree in applied physics. Now Paul works as an engineer, and he’s glad that he chose to major in physics. He thinks his physics background broadens his career options, and would help him succeed in a number of different fields. In addition to making him versatile, studying physics gave him an invaluable skill. “You get that ability to walk into strange situations, unfamiliar situations, and think from what I call basic principles; to use a basic understanding of how the world works in order to solve the problem.”



Although Paul spent much of his career in disk drives, he recently moved into a new field—solar power. His goal is to use thin-film technology to create less expensive solar cells. Making the cells cheaper would make solar power more affordable and more likely to be widely used. That would help clean up the environment. “If I’m successful, if this industry is successful, we will have changed the world for the better.”

DID YOU KNOW...

That a physicist, John Atanasoff, invented the first electronic digital computer in 1939. Read more about him online at <http://www.johnatanasoff.com>.



“Without that program, I wouldn’t have realized I could go to an Ivy League school.”



When Kelle Cruz was a teenager,

she started to think about big questions, like why am I here? What is it all about? She remembers going camping, gazing at the stars and wondering about questions like these. When she was a junior in high school, she decided she wanted to become an astronomer.

“I thought it was a concrete way of trying to figure out what it is all about,” she said. Now a postdoctoral student at the California Institute of Technology in Pasadena, California, Kelle studies a kind of celestial body called brown dwarfs to better understand planets outside our solar system. She plans to eventually become a university professor.

Kelle wasn’t always interested in the life of a professor. In middle school she thought she might want to be an entrepreneur like her father, who sold light bulbs to restaurants. She liked working with numbers, and helped her father with accounting and bills. When Kelle was growing up, her mother worked as a part-time property manager and administrative assistant. Neither of Kelle’s parents went to college.

But the summer after Kelle’s eighth grade year, she attended a special summer math and technology program. She had always liked and been good at math and science, and the program gave her the opportunity to learn more about both. For the next two summers she joined the program, which was held on college

campuses in her native San Antonio, Texas. Through the program she could use the college library, and her classes were taught by professors at the colleges. The whole experience opened her eyes to the opportunities available to her.

“Without that program, I wouldn’t have realized I could go to an Ivy League school,” she said. Kelle went to the University of Pennsylvania planning to become an astronomer. She graduated with a degree in physics, focusing in astronomy.

After graduation, she continued at the same university to get her Ph.D. While studying for this degree, she began to study brown dwarfs. Brown dwarfs are exciting because they are the link between stars and planets, Kelle said. Physicists and astronomers think brown dwarfs form in the same way that stars do, but in many ways they look like planets. Astronomers want to learn more about how planets form, but far-away planets are difficult to study in detail because the light they emit is faint, she said. Brown dwarfs give off a stronger light, making them easier to study. If Kelle and other astronomers study brown dwarfs, they will be better prepared to study planets when they can be studied, she said.

Only in the past few years have researchers recognized there are planets outside our solar system, but now many have been found, Kelle said. The goal of the kind of research Kelle does is “finding earthlike planets that might harbor life,” she said.

meet Kelle





How light is produced

An atom contains a positively-charged nucleus that has negatively-charged electrons circling it in many different orbits. The electrons circling closer to the nucleus are in a lower energy state and those further away are in a higher energy state. If heat, electricity, or any other kind of energy is applied to the atom, the electrons jump from lower orbits or energy states to higher energy states. However, electrons want to return to their lower energy state or ground state. As they return to the ground state, the electrons give off energy in the form of photons or light. Lots of excited atoms whose electrons are moving back to their lower energy states can produce the light that we see.

“I knew that [physics] was for me...the idea that you can understand everything starting with physics.”



As a young child growing up in Cuba, Alejandro Rodriguez didn't plan to become a physicist. “Until

I was 13 or 14 my mom thought I would be a botanist, because I always liked plants,” he said. It wasn't until his sophomore year in high school, several years after he, his mother and his stepfather came to the United States, that Alex decided he wanted to pursue physics. Now a graduate student at MIT in Massachusetts, Alex studies the properties of light involved in lasers and optical fibers, which are used for telecommunications.

Although Alex's stepfather and mother were both physics professors in Cuba, neither was able to teach physics in the United States. They also didn't push Alex to pursue a physics degree. In fact, when Alex was growing up, his stepfather spoke very little about his physics career. “He kind of blocked that part of his life,” Alex said. “He really, really liked what he was doing, so the fact that he had to stop, I guess, affected him a lot.”

Alex knew that generally you have to get very good grades to succeed in physics, but he did not fit that mold until he was a sophomore in high school. As a freshman, he got “mediocre” grades, and although he was good in math, when his teachers tried to pass him from geometry to geometry honors, he wasn't interested. But his attitude about school and grades completely changed during his sophomore year after he took his first computer science and physics classes. It was then “I knew that [physics] was for me,” he said. He was fascinated by “the idea that you can understand everything starting from physics,” he said. From there, he was hooked.

Once he knew that he was passionate about physics, Alex was determined to do whatever he needed to do to

succeed in it. This included getting into MIT, which he heard “was the best place to study the hard sciences.” In order to be accepted, he had to bring his grades up quickly. In his junior year of high school, he took seven advanced placement classes, and also started taking classes at Florida International University. Although, he was ranked in the 200s as a freshman, by the end of high school, he shared the #1 spot in his class and was accepted to MIT. He finished with a physics bachelor's degree in three years, and went straight on to his doctorate program.

Alex plans to continue working in physics after he finishes his graduate degree. He likes the idea of becoming a professor, or working as a researcher for a national laboratory. He would also consider starting his own company, if “something good comes up,” he said. But even if Alex hadn't decided to continue in physics, he feels his physics degree would be worthwhile. Studying physics, “teaches you to think about many different things in many different ways; to think analytically,” he said.

According to Alex, his stepfather is an example of why the ability to think differently and analytically is so valuable. His stepfather was forced to stop teaching in Cuba, and he came to the United States to provide for his family. In the US, his credentials weren't accepted and he wasn't able to teach again. Instead, he drove a truck and worked in construction to earn money for the family. But years later, after coming to the US with almost nothing, Alex's stepfather is now a chief editor at Univision, a Spanish-language media company. His stepfather credits part of his success to his ability to solve problems and think outside the box, and that comes directly from his physics background.

meet Alejandro

how to prepare

GETTING READY FOR A CAREER IN PHYSICS

The Language of Physics

So are you ready to take off on an exciting voyage into the world of physics, where you get to solve cool problems and create new technologies? Well, the best way to prepare is to learn the language of physics—math. Math is the tool physicists use to explain and predict how all things in the universe, both large and small, behave. Before Kelle Cruz could study distant brown dwarf stars or Marta Dark McNeese could help injured athletes play their sports again, they both took the time to learn a lot of math. If you want to become a physicist, you'll want to study math too!

Taking math classes and doing your best in them will prepare you to study physics (or any science) once you get to college. If your school offers advanced math classes, consider taking them. Most schools also offer general and advanced physics and chemistry. Taking those classes will give you an edge once you get to college, and even though they may seem challenging, they can be fascinating too. Many physicists say that it was in a middle or high school physical science class that their eyes were first opened to the wonders of physics.

Extra Help

If math and science come easy to you, then you're one of the lucky ones, but if math and science aren't the easiest classes for you, you're not alone. Many students can use extra help. Talk to your teachers and parents about options that can help you improve and build your confidence, like getting a tutor or spending time after class going over your work with your teacher. You can also make learning even more enjoyable by forming a study group with your friends to help each other learn.

Science Camps and Programs

There are lots of cool science education opportunities outside of your school too. Many camps and summer programs are available for students who want to learn

more about physics and other sciences. These programs let you work with all kinds of materials, doing science experiments and testing out your ideas. For more information on camps and other programs, talk with your guidance counselor or search online for science programs for middle and high school students.



Many physicists say that it was in their middle school or high school physical science class that their eyes were first opened to the wonders of physics.

College Preparation

Once you've taken your middle and high school math and science classes, and you've decided you want to learn more physics, it's time to think about college. There are several things you should do to prepare for college physics and college in general. First, do your best in your high



school classes, and take either the Scholastic Aptitude Test (SAT), the American College Test (ACT), or both. Colleges use these tests, along with your grades, your written essays, and letters from some of your teachers, to evaluate your college application. It's a good idea to get to know your high school math and science teachers, and let them get to know you and your work, so they can write strong letters of recommendation for your college applications.

What to do in College

If you've been accepted to college, you should be proud of yourself. Now that you're there, find the physics department and pay them a visit. This might seem a little intimidating, but the physics professors and staff are there to help you, and you should take advantage of them. The first person you will encounter might be the physics department secretary. Introduce yourself as a freshman who is interested in studying physics, and ask whether there is someone you can talk with about choosing your courses. The department will have a faculty member who can advise you. Set up a meeting with this person and talk about the things that excite you in physics. He or she will direct you to courses and resources in the department and the college that will get you started on a fascinating journey into the world of physics.

Your parents and teachers can also help you succeed in math and science. Here is some information you can give them to help them help you.

For Parents

Studies have found that parents are a key part of their son's or daughter's academic success. If your child is interested in math and science, you can support him or her by encouraging those interests and providing the time and opportunities for your child to study and explore his or her interests. It could certainly be worthwhile—a physics degree is a passport to many different and rewarding careers that offer good salaries. It's also noteworthy that people with physics undergraduate degrees have one of the lowest unemployment rates of any field.

If you think physics could be a good choice for your child, encourage him or her to take general and advanced math and science classes and to work hard in them. If you are interested in finding a tutor for your child, your child's teacher or an administrator at your child's school should be able to help. Also think about available options outside of school, such as summer camps and programs. Some colleges and universities have low or no cost programs for middle and high school students to learn more about science and technology. Contact schools in your area to inquire about these programs.

For Teachers

Teachers can help students succeed in physics by working closely with students who are interested in math and science, and using a hands-on teaching approach including simple inexpensive experiments to help students understand how exciting physics can be. Many everyday objects can be used to help students better understand physical forces. There are also many resources for teachers to encourage their students' creativity and scientific thinking on the Internet. Teachers should check out <http://www.aps.org/studentsandeducators/> for links to those resources.

Finally, physics teachers should consider joining associations such as the American Association of Physics Teachers (www.aapt.org) and the National Science Teacher Association (www.nsta.org) for professional development opportunities and additional resources.

paying for your education



FINANCIAL AID AVAILABLE FOR PHYSICS EDUCATION

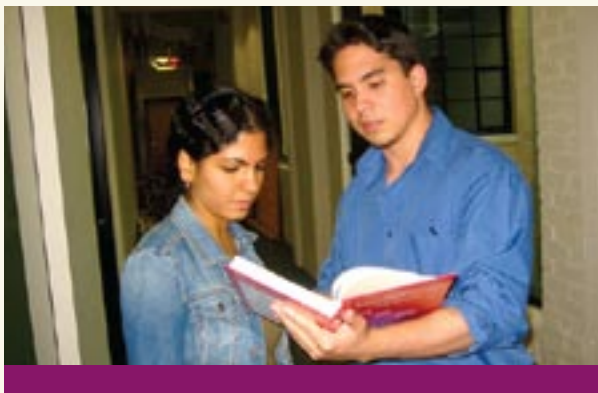
Many high schools maintain a list of scholarships that students might qualify for based on interests and hobbies, academic skills, race and ethnicity or background.

Would you like to study the secrets of the universe like Keivan Stassun, help save people's lives like Albin Gonzalez, or develop technologies to clean up the environment like Paul Markoff Johnson? College is the first step. College or university tuition might seem expensive, but there are plenty of places you and your parents can go for help.

First, you can come to us! The American Physical Society offers a scholarship for minority students who plan to major in physics. You can use the money for tuition, living expenses, or books and other supplies. For more information on this or other scholarships, visit our web site at MinoritiesInPhysics.org.

Talk to your high school's guidance counselor. Many high schools maintain a list of scholarships that students might qualify for based on interests and hobbies, academic skills, race and ethnicity, or background. Next, talk with someone in the financial aid office at the college where you have applied. Most colleges offer scholarships to admitted students, as well as opportunities for upper level students to do paid research.

The federal government is another good place to go for college cash. The federal Pell Grant, for example, can provide up to \$4300 per year as of the 2007-2008 academic year. Students majoring in physics can also qualify for the National Science & Mathematics Access to Retain Talent Grant (National SMART Grant), which provides up to \$4000 per year for a student's third and fourth years. In addition to grants, the federal government has a number of loan programs. For more information, visit the U. S. Department of Education's Student Aid on the Web site at StudentAid.ed.gov.



Independent websites are another place to look for money for college. FastWeb! (fastweb.com) provides information on scholarships and also gives profiles of many different schools. You can also check out FinAid! (finaid.org), and Scholarships.com*. Both sites provide information on scholarships, loans, and ways to save for college.

What if you decide you don't want to stop studying after you graduate from college? If you're interested in physics, you'll get a lot of help to continue your studies. Almost all graduate students in physics have their tuition paid by their physics department or universities. In fact, most also get money for living expenses through research fellowships or teaching!

For more information, visit MinoritiesInPhysics.org.

*Scholarship portals like Finaid.org, Scholarships.com and FastWeb! are listed for information purposes only. The American Physical Society does not endorse any of these services.



Physics and microphones

That ninety percent of all microphones in use today are based on the invention of James E. West, an African-American scientist and inventor? West, along with a co-inventor, created the electret microphone in the 1960s. Microphones work by converting sound waves into digital signals. West's version became very popular because it does this reliably and accurately, and can be made very inexpensively.

potential earnings

SALARY SCALES FOR PHYSICS PROFESSIONS



What would I do and how much would I earn?

As you've seen in this brochure, people with physics degrees work in many exciting fields. With a physics degree, you could teach at a junior college, like Lynett Rock. You could study space, like Kelle Cruz. Or you could help clean up our planet, like Paul Markoff-Johnson.

How much money you would make in jobs like these depends on your level of education, how much experience you have, and where you choose to work. Private companies typically employ the largest number of physics degree holders and offer some of the highest starting salaries.



Starting salaries*

Bachelor's degree

Most people with a bachelor's degree in physics work in science-related jobs. These jobs are in software and engineering, science teaching, and

managing in technology-related companies. Typical starting salaries for new physics bachelor's degree recipients in science related jobs in private companies range from \$33,000-\$54,000.

Although there are many employment opportunities for physics bachelor degree holders, two-thirds ultimately decide to get an additional degree in physics or another field.

Master's and doctorate degrees

For people who earn a master's degree in physics, typical starting salaries in private companies range from \$43,000-\$70,000.

For individuals with physics doctorates (Ph.D.s), typical starting salaries in private companies range from \$69,000-\$90,000. Later on in their careers, many people with physics doctorates can expect to earn more. In 2004, the median salary for people with Ph.D.s in physics was \$90,000, and \$104,000 for people working in industry. People with physics doctorates working in hospitals or medical services had a median salary of \$120,000. In 2006, the average salary for a university assistant professor within 5 years of receiving his or her Ph.D. was \$60,000.

All salary and career information here comes from the American Institute of Physics' Statistical Research Center.

* All salary figures provided here are the most recent available as of 2007.

for more information

CHECK OUT THESE LINKS FOR MORE INFORMATION

Physicists like Nadya Mason and Kelle Cruz decided to study physics partly because of fun summer programs that they participated in when they were young. A summer program could be a good way for you to decide if you'd like to study physics.

If you're interested in summer science programs or other science programs outside your school, here are a few places you can go.

Fermilab

Fermilab, a federal physics laboratory, has a list of educational programs available to students and teachers. These programs can be found at eddata.fnal.gov/lasso/program_search/calendar_sciadv.lasso

The laboratory's address is
Education Office
Fermilab MS 226
Box 500
Batavia, IL 60510
tel: 630-840-3092
fax: 630-840-8248

Venture Scholars

The Ventures Scholars program helps students from underrepresented minority groups succeed in achieving careers in math and the sciences. For more information contact:

Maxine Bleich, President
Ventures Scholars Program
c/o Ventures In Education, Inc.
15 Maiden Lane, Suite 200
New York, NY 10038
212-566-2522 ext. 122

For a list of more programs and opportunities, visit the companion web site to this brochure online at: <http://MinoritiesInPhysics.org>

1-800-94-SMART ext. 122
mbleich@vesc-education.com
Or visit www.venturescholar.org

Math Engineering Science Achievement

MESA (Math Engineering Science Achievement) helps middle, high school and college students succeed in math and science and get degrees in engineering, technology and the sciences. It also helps science teachers. MESA programs exist in a number of states including Arizona, California, Colorado, Maryland, New Mexico, Oregon, Utah and Washington. For more information contact the California office at:

MESA Statewide Office
300 Lakeside Drive, 7th Floor
Oakland, CA 94612-3550
tel: 510-987-9337
fax: 510-763-4704

For contact information on programs in other states visit www.ucop.edu/mesa/about/mesausa.html

For a list of more programs and opportunities visit the companion web site to this brochure at MinoritiesInPhysics.org.



AMERICAN PHYSICAL SOCIETY

One Physics Ellipse
College Park, MD 20740-3844
Tel: 301-209-3232
Fax: 301-209-0865
Email: minority@aps.org

Explore, Understand Succeed: Physics!

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Project Manager and Editor: Arlene Modeste Knowles
Graphic Designer: Krystal Ferguson
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