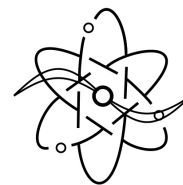


# THE QUARK



Brought to you by The Society of Physics Students

## High Octane

*By Akash Maheshwari*

Every time you go to the gas station, you lift the nozzle and select a grade of fuel: regular, mid-grade or premium. But have you ever considered what those large bold numbers on each button mean? Have you ever noticed that those numbers that correspond to each grade of fuel are not always the same, but rather change depending on your location?

On a recent trip down to the southern part of the state, I was perplexed by how the regular grade of fuel changed from a rating of 86 to 87 octane. My car's manual had clearly stated that the vehicle runs on 87 octane gas. How then could I drive my car without engine knocking in Lubbock where the regular grade of gas was 86 octane? The answer to this question first requires an explanation of octane ratings. Octanes are organic hydrocarbons that consist of 8 saturated carbons in a chain. One specific type of octane, isooctane, is used as a reference molecule to quantify the tendency of gasoline to self-ignite in a combustion reaction. Octane ratings are, simply put, a measure of gasoline's resistance to uncontrolled detonation. Higher octane rated fuels are less likely to combust spontaneously at higher pressures. The engines of cars have a specific compression ratio that dictates the pressure and heat required for a typical detonation of a piston. Compression ratios compare the volume of the cylinder during the intake stroke to the volume of the cylinder during the compression stroke.

To understand this better, we will examine the combustion process of a single piston (see figure below). The piston begins far away from the top of the cylinder, allowing a mixture of gasoline and air to be present in the cylinder. The piston then moves upward, compressing the gas/air mixture. Once the gas/air mixture reaches its peak compression state (highest pressure and greatest

### Contents

- High Octane
- Professor Spotlight: Dr. Juyang Huang
- Student Spotlight: Cristobal Moreno
- Looking Back on the Semester

### About The Quark

The Quark is a monthly newsletter provided by the Public Relations Committee of the Society of Physics Students (SPS). Our goal is to help new students become more familiar with the Physics Department and give returning students more insight on aspects of the department they might not have been aware about.

If you have any questions about The Quark or SPS, you can email our Public Relations Officer ([shanmuga.shivakumar@ttu.edu](mailto:shanmuga.shivakumar@ttu.edu))

amount of heat), the spark plug will ignite this mixture. The piston will be pushed down, generating a force that can do useful work. However, if the fuel combusts before peak compression, harmful engine knocking will be observed. In performance cars with higher compression engines, higher octane fuel is needed to withstand more pressure and heat before combusting. In most cars, regular gas with 87 octane is suggested for use because these cars have lower compression ratios and therefore require a fuel that will combust under conditions of less pressure and heat. So why does the octane rating of regular grade gas change from place to place?

### Four-stroke cycle

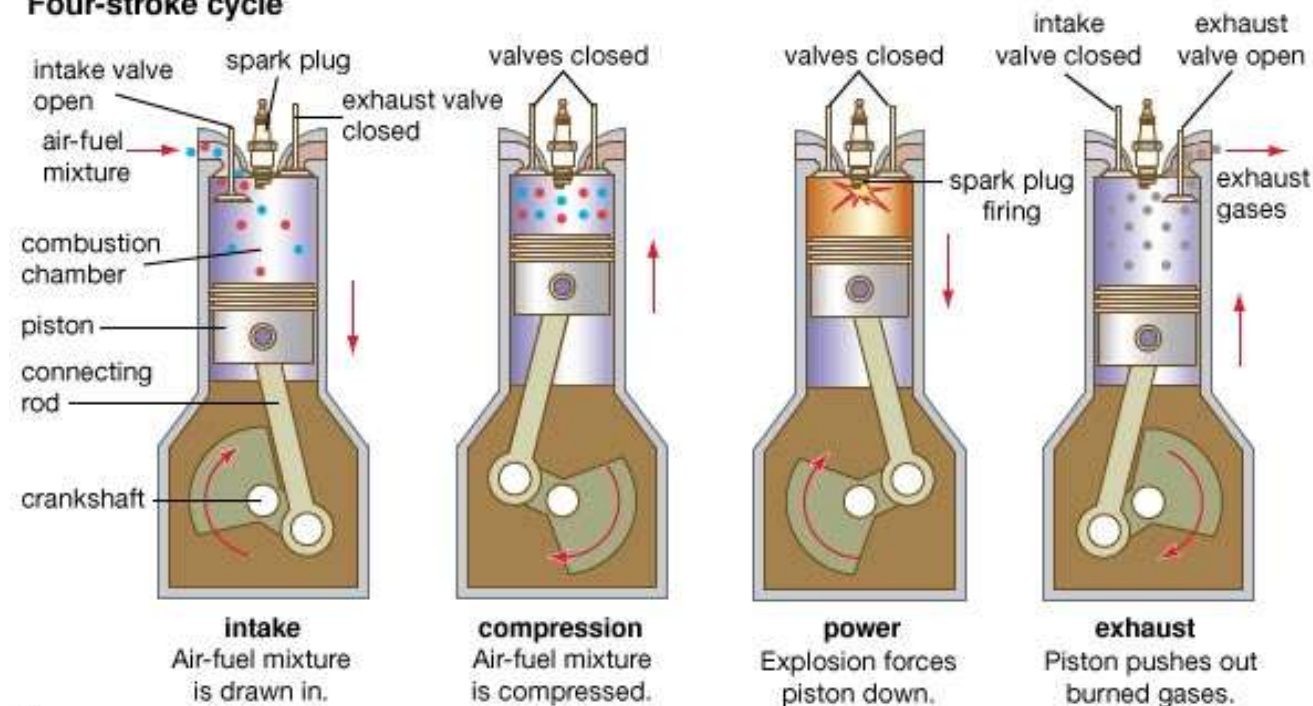


Diagram of Single Piston going through a four-stroke cycle [5]

The answer is due to the effects of elevation. At higher elevations, you will find octane ratings are lower for each grade of gas. By considering the case of an individual piston, we can observe why this phenomenon is observed. At higher elevations, gas molecules of the atmosphere are observed to be of lower density. This result is observed because the gravitational force that the Earth exerts on each individual gas molecule is greatly diminished as the distance from the mass of Earth increases. Since the air that will be going into each cylinder is essentially 'thinner' and possesses less oxygen, that means that there will be less pressure during the compression stroke. This is equivalent to having a lower compression ratio. As discussed earlier, a lower compression ratio requires a lower octane rating of fuel. If a higher octane is used, not all of the fuel will be combusted and waste products are produced.

Cars are something that we use on a daily basis, yet there are so many fascinating details that we fail to appreciate about the modern automobile. The seamless integration of so many different types of technologies and scientific principles that culminate in the creation of an automobile is an intriguing concept to consider.

## Professor Spotlight: Dr. Juyang Huang

*By Ian Garcia*

When people think of the word “career,” they often visualize a straight, narrow, somewhat clear path towards an ideal job or state of living. In reality, many individuals will meddle in areas that they never envisioned, or end in a field completely separate from the one they began in. Dr. Juyang Huang is one of these people, starting out his life with an intense love for electronics, so much so that he would build his own machines, and now is currently working in the field of biophysics with special adherence to the cell membrane.



### What got you into physics?

“At a young age you just don’t know what is best, or you have a lot of selections. I was really interested in electronics, so I built my radios, televisions, from the discreet elements, when I was in high school. When I applied to colleges, the closest thing I could find was physics.”

Dr. Huang began his college years at Zhejiang University in Hangzhou, earning his Bachelor’s in Physics, and moved on to get his Master’s in Computer Engineering at the University at Buffalo in Buffalo, New York. He stayed there to get his PhD, studying the liquid crystal display, or LCD, a display commonly found in smartphones, televisions, and instrument panels. Dr. Huang seemingly had his life in a straight order, following electronics for most of his life. When it came to his Postdoc at Cornell University, however, he started his similar yet vastly different path.

“The lab studied the lipid membrane, and the lipid membrane is kind of similar to some liquid crystal; two-dimensional, the structure of certain molecules. So that’s why I ended up in the study of biophysics, the lipid membrane aspect.”

### So, what kind of research do you do now at Texas Tech?

“Why is it important to study cholesterol? Cholesterol is very important to mammalian cells, and the people are always wondering ‘Why is the cholesterol in the membrane, and what properties will change when you add cholesterol into the membrane?’ That’s the main topic of my study; what is the main role of cholesterol in the membrane?”

## IHOP Give Back Night

SPS held it's second give back night November 15th. We had a great turnout and lots of fun! Here are some pictures from our past two IHOP events:



A big thank you to everyone who came and supported SPS. Hope to see everyone at the next one!

Dr. Huang works on understanding the main role of cholesterol in the lipid bilayer that surrounds the cell. The lipid bilayer is essentially the envelope that surrounds the cell's organelles and protects them from the outer world. Dr. Huang's original theory, the only one that remains today, is that cholesterol follows an umbrella model. It has a tiny hydrophilic head compared to its giant hydrophobic water, so to protect the rest of the cholesterol molecule, it uses the nearby lipids as an umbrella, and also adds to the overall flexibility of the membrane. Dr. Huang and his two undergraduate assistants are currently creating computer models of his theory at the molecular level, further studying the properties of the cell membrane and its many components.

### What is it like to work under you, and do you have any advice to tell students?

"Our research has some people doing computation, some people are doing the experiment, but together we try to understand more about the membrane system with the cholesterol. They all go together. We make certain predictions so we can verify with the simulation, see how that works, and make measurements to verify those. It's a very exciting field, because there are still a lot of questions that are still unsolved.

People have different talents. Some people are really good at calculations, some people are really comfortable with handling computers, some people are just very comfortable doing the experiment hands-on. So you cannot measure the scientific talent on 'Did you get a C in this class? Did you get an A in this class?' When you go into research, your capability cannot be measured by just your GPA. If you are really good at hands-on and you do computation you are not going to do well.

What type of work will give you joy when you do the research? If you say 'I have to get this measurement, I have to do this' you are not going to do well. If you say 'I can do this, I'm going to make this measurement, I really want to know what the result will be,' then you are doing the research you are supposed to be doing."



Dr. Huang has varied in his career interest throughout his entire life, from starting with radios to cholesterol today. As someone who has done different things, and been in many different places, his main point of advice to give to students is to constantly try everything, find what you are good at, and to continue at it. If you are not good in an area, but still hold passion to it, then continue to try in different methods at the same area, like computation or experimentation rather than computers. You, like Dr. Huang, will eventually find your way.

## Student Spotlight: Cristobal Moreno

*By Ivan Cornejo*

Video games have been an inspiration to many people, and for Cristobal Moreno, video games became a gateway into science. For him, games such as Metroid and other futuristic titles made him question why we as a civilization aren't that advanced yet. In middle school, it became clear that he wanted to get into STEM, which began his journey into physics. He joined a program held by the now University of Texas at Rio Grande Valley (formerly the University of Texas-Pan American) which was a chance for him and a few others to go to a series of talks. There, he listened to a speech by Michio Kaku, a popular theoretical physicist and futurist, who talked about his ideas and predictions of what the future of society would look like. Chris wanted to be able to make that future a reality, and that is what led him to want to become a physicist. What led him to come to Texas Tech was the PI2 program that started 2017. This program allows undergraduates to learn about and start research. For Chris, this is what was important to him. What solidified his choice in attending Texas Tech was the Physics Department's strong high energy physics group.



Chris, with the help of the PI2 program, joined a research group as soon as he could. He is currently doing research with the high energy group, specifically under Dr. Kunori, as well as working with another individual. Chris is doing two projects under the high energy group, which involve tomography and calorimetry, respectively. Tomography, in its most basic definition, is the cross sectioning of an object or structure using penetrating waves. However, specifically for the group Chris works under, they are building their own "muon telescopes" or tomography detectors that use muons to

penetrate and create 3D images of man-made structures. He mostly worked on helping to build the detector itself as well as looking at data and running Monte Carlo simulations for said data. The second project is calorimetry, which, for the purpose of their research group, is when high energy particles pass through a material, leaving heat that can be detected and measured. However, Chris stated that it is relatively new research for the group and that he does not entirely know why they are working on the project. Chris has also started working with the new physics professor, Dr. Kim, to do research based in quantum computing. However this is relatively new research, so he is still just learning what quantum computing is.

Chris' future goals are to get into graduate school with a specific focus on nuclear and particle physics. Then, he wants to try and research topics such as the breaking apart of particles. He also wants to work at places like CERN or Fermilab, but these aren't the only ones he wants to apply to, he really just wants to work at labs and in lab environments. His advice to freshmen is to not underestimate the physics major, as to some it may seem easy but at higher levels it is more difficult as well as more time consuming. "In order to be a physicist, you should be willing to sacrifice some of your social life, and to not join the major if money is your only goal because it isn't worth the pain." Specifically, for research, he said if you find research that you're interested in, go and talk to the professor and ask them about it, especially in person.

## Looking Back on the Semester

*Pictures Taken by Alexandria Clark (SPS Historian)*

As the semester winds down and finals draw ever closer, SPS would like to share some pics of a couple of events we organized/helped out with this fall semester. If you would like to join SPS and be apart of future events, join our org page on TechConnect or contact our Secretary ([cheslee.hibler@ttu.edu](mailto:cheslee.hibler@ttu.edu)) to be added to our email list.

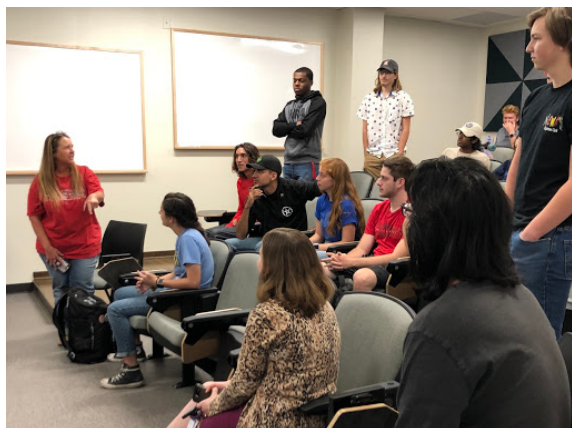
We hope everyone has a safe trip home and Happy Holidays!

### General Meetings

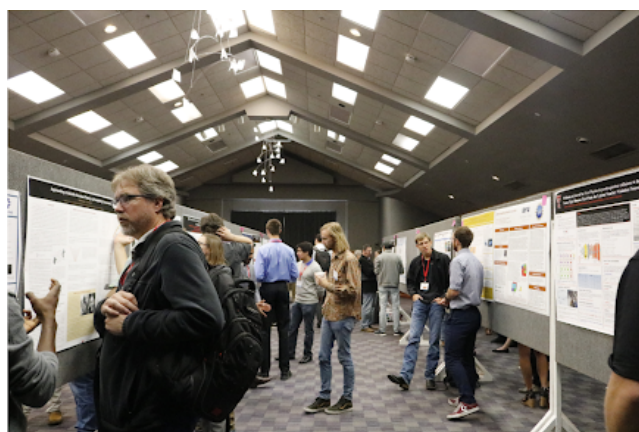




## Welcome Back Bash



## 2019 Texas Section of the American Physical Society Conference



## Amarillo Day



## References:

[1] Walker, James S. **Physics**. Pearson, 2016.

[2] Brown, Theodore E. **Chemistry: The Central Science**. Pearson, 2017.

[3] <https://www.vroomgirls.com/all-about-octane/>

[4] <https://www.popularmechanics.com/cars/how-to/a5308/4345737/>

[5] <https://www.britannica.com/technology/four-stroke-cycle>

[6] [https://www.depts.ttu.edu/phas/People/Faculty/bio\\_huang/bio\\_Huang.php](https://www.depts.ttu.edu/phas/People/Faculty/bio_huang/bio_Huang.php)

[7] Huang, J. (n.d.). **Biophysics Research of Cell Membranes**.

## Acknowledgements

The Public Relations Committee of the Society of Physics Students would like to thank the following people for contributing to the success of this month's edition of the *Quark*:

- Dr. Juyang Huang
- Cristobal Moreno

## Writers

- Akash Maheshwari
- Ian Garcia
- Ivan Cornejo

## Editors

- Shanmuga Shivakumar (Editor in Chief)
- Ian Garcia
- Ivan Cornejo

