PROJECT TOPIC LIST

SUPERVISOR	FIELD AND PROJECT NUMBER	TITLE/DESCRIPTION	CONTACT
Dr. Matt Benacquista	astronomy/ astrophysics **1**	**Observations of Compact Binaries in Globular Clusters** There have been many observational campaigns directed at detecting the population of binary systems containing white dwarfs, neutron stars, and black holes within the Galactic globular cluster system. This project would perform a literature search of recent observations and produce a small catalog listing the numbers and types of compact binaries for each globular cluster in the Galactic system.	benacquista@phys.utb.edu
Dr. Gianpietro Cagnoli	engineering/ materials **2**	**Building the most perfect reference system** How perfectly still can an object be on Earth? This question may seem just purely academic but in reality several experiments and devices like Gravitational Wave detectors, electronic and atomic force microscopes, and light tweezers, to cite few of them, need the most stable position reference system one can achieve in a laboratory. The proposed project will concentrate on the suspension systems of gravitational detectors like LIGO and Virgo where objects are held in position within 10^{-12} m. Simple mechanical devices can be developed, too.	Gianpietro.Cagnoli@utb.edu
Dr. Gianpietro Cagnoli	engineering/ materials **3**	**Keeping the right time** During different ages people have developed several types of watches or time keepers, from the sand and water watches of the Roman Empire to the atomic clocks of modern times. This project aims to find a common working principle for all of these kinds of clocks. Students working on this project might get a chance to examine an atomic clock based on Iodine transition that is being assembled in the Optics Lab at the Physics Department.	Gianpietro.Cagnoli@utb.edu
Dr. Gianpietro Cagnoli	Optics **4**	**The science of 3D imaging** Did you enjoyed Avatar 3D? How it is possible to recreate the 3D perception out of a 2D image? If you want to have an insight on this technique and maybe design a homemade 3D imaging system you may consider to do some research on this topic. The project consists of studying all the different techniques that have been developed so	Gianpietro.Cagnoli@utb.edu

		far for the 3D imaging and then concentrate on the current technology that uses the circular polarized light. At the end you may design a 3D imaging system that can be mounted at your school.	
Dr. Mario Diaz	astronomy **5**	**Observation of variable stars** Students will record the variable luminosity of variable stars to obtain the period of variation and other information and compared it with existing records. This project will require time at the Nompuewenu Observatory at UTB	mario@phys.utb.edu
Dr. Mario Diaz	astronomy **6**	**Radio Telescope** Construction of a radio telescope to observe molecular hydrogen distribution in the galaxy	mario@phys.utb.edu
Dr. Karen Martirosyan	nano-scale science **7**	**Advanced Nanostructured Materials and Devices** We, humans, live on a scale of meters and kilometers, so it's quite hard for us to imagine a world that's too small as nanometer scale. Making new things on this incredibly small scale is called nanotechnology or nanoscale science and it's one of the most exciting and fast-moving areas of science and technology today. This multitask project will allow students to review the fundamental understanding of fabrication of nanomaterials and nanostructured devices for energy, environment and biomedical applications.	Karen.Martirosyan@utb.edu
Dr. Karen Martirosyan	nano-scale science **8**	**Propulsion and Explosive NanoSystems** Most of nanotechnology's benefits will happen decades in the future, but it's already helping to improve our world in many different ways. For example nanoenergetic materials can be used for many aerospace and military applications. The main subject of this project is to review the physics based knowledge in energy release, shock waves and pressure discharge needed to enhance the performance and functionality of highly energetic nanostructured systems to apply their insertion in several propulsion and explosive systems.	Karen.Martirosyan@utb.edu
Dr. Karen Martirosyan	biophysics and nano-scale science **9**	**Nanoparticles for Cancer Therapy and Imaging:** We tend to think of nanotechnology as something new and alien, perhaps because the word "technology" implies artificial and human-made, but nature itself is an example of nanotechnology: proteins, bacteria, viruses, and cells all work on the nanoscopic scale. This project will allow student to learn about superparamagnetic	Karen.Martirosyan@utb.edu

		phenomena arising from finite size and surface effects that dominate the magnetic behavior of individual nanoparticles that designed to use in cancer therapy, drug delivery and advanced imaging.	
Dr. Karen Martirosyan	lunar and planetary science **10**	**Advanced Materials for Lunar Exploration Program:** As major space agencies from US, Europe, Russia, and China turn their exploration ambitions towards the Moon, the research and development of new technologies for Lunar operations require meeting a fast pace schedule, reminiscent of the 1960's Apollo program. Fabrication of structural and refractory materials from in-situ lunar resources (metals, ceramics, or composite-based materials) will be essential for enabling extended human presence on the Moon.	Karen.Martirosyan@utb.edu
Dr. Volker Quetschke	lasers **11**	**The Laser - History and Applications** From high precision metrology to medical applications, a lot of modern technology would not be possible without the invention of the laser. In this project the student will describe the core elements that constitute a laser, its history and showcase applications that use its unique properties.	Volker.Quetschke@utb.edu
Dr. Volker Quetschke	optics **12**	**Input optics for LIGO** LIGO is the first detector capable for direct observation of gravitational waves. Gravitational waves, as predicted by Einstein, are the distortions of spacetime itself but manifest themselves as tiny length changes of measurable distances. In this project the student will describe the technologies that are necessary to prepare a laser beam with sufficient quality to be used for interferometric gravitational wave detection - such as with LIGO - and showcase the achievements of LIGO's input optics.	Volker.Quetschke@utb.edu
Dr. Malik Rakhmanov	gravitational wave detection **13**	**LIGO -- the Laser Interferometer for Gravitational-wave Observatory** LIGO is the first detector capable for direct observation of gravitational waves. Predicted by Einstein, gravitational waves are not traveling through spacetime, they are the distortions of spacetime itself. These distortions are produced by massive stellar objects which are orbiting each other such as binary neutron stars, or binary black holes. In this project the student will describe the principles of gravitational wave detection, explain the technological challenges	malik.rakhmanov@gmail.com

		faced in operation of such detectors, and give an update on their current status.	
Dr. Malik Rakhmanov	optics **14**	**Propagation of Light in Negative Index Materials (NIM)** Negative Index Materials (NIM) present fundamentally new way to manipulate light and shape its propagation through matter. Particularly interesting are the projects that lead to perfect lenses and invisibility cloaks. In this project, the student will describe the basic physical properties of NIM, outline how it can be used to fabricate a perfect lens (the lens free of spherical aberration) and explain why invisibility cloaks are possible and what technological challenges must be met when fabricating such devices.	malik.rakhmanov@gmail.com
Dr. Malik Rakhmanov	photonics **15**	**Optical Properties of Synthetic Opals** Synthetic opals are photonic crystals made of silica nanospheres which are arranged in a face-centered cubic (FCC) lattice to form a crystal. The periodic structure of the photonic crystals leads to interesting new phenomena such as photonic bands and band gaps similar to those known in semiconductor materials. As a result, these new materials possess rather unusual optical properties. In particular, it is expected that the synthetic opals can exhibit negative index of refraction under certain conditions. In this project, the student will explain how light is propagating through synthetic opals and why it should experience negative refraction.	malik.rakhmanov@gmail.com
Dr. Malik Rakhmanov	relativity **16**	**The Apparent Weight of Photons** General Relativity predicts that photons are affected by gravity. For example, photons which travel from Sun to Earth lose their kinetic energy as they overcome the gravitational pull of the Sun. Since their kinetic energy is proportional to their frequency, the effect of the Sun is that the photons frequency spectrum is shifted toward the red end, which is why it is called the gravitational red shift of light. This effect plays a big role in the GPS navigation system and is crucial for ultra-stable clocks on Earth. In this project, the student will give a brief history of red-shift experiments, explain why this effect is important for GPS, and speculate on how future ultra-stable clocks in orbit can utilize this effect in their principle of operation.	malik.rakhmanov@gmail.com
Dr. Malik Rakhmanov	optics	**The Archimedes Codex**	malik.rakhmanov@gmail.com

	17	In 1998 a medieval prayer book was sold on an auction in New York for two million dollars. The prayers and the religious images on the pages of this book were written on top of the ancient text containing mathematical proofs of legendary Archimedes, whose genius discoveries shaped the development of modern mathematics, physics, and engineering. The Archimedes' text was erased by the medieval scribes to re-use the parchment for a prayer book. And yet, today, using the modern tools of physics research, it was possible to read under the prayers and restore the ancient writings of Archimedes. What are these modern tools and how they were used to restore the Archimedes' book?	
Dr. Joe Romano	cryptography **18**	**Cryptography** Cryptography---the art of secret communication---has been around for countless centuries, used whenever someone wants to hide the meaning of a private message from intruding eyes. In this project, the student will survey several of the algorithms used to encipher and decipher messages, including the RSA algorithm and PGP (Pretty Good Privacy) protocol used to keep our internet transactions safe from eavesdroppers. This project requires basic computer programming skills on the part of the student.	joe@phys.utb.edu
Robert Stone	gravitational wave detector/ seismic studies **19**	**Keep the Noise Down!** The Laser Interferometer Gravitational-Wave Observatory (LIGO) can (amazingly!) measure distances smaller than a proton diameter, but it is extremely sensitive to seismic activity. In this project students will investigate how different kinds of seismic noise (earthquakes, ocean tides, traffic, storms, etc.) affect LIGO's search for gravitational waves, how the seismic noise is monitored, and what steps are taken to limit its effect.	rstone@phys.utb.edu
Dr. Ahmed Touhami	nanoscience/ nanotechnology **20**	**Atomic Force Microscopy** Nanotechnology is going to significantly change our future. Some prognoses say that its impact on our lives will rival that brought about by the steam engine, electricity, the transistor, and the internet. One of the most important acronyms in nanotechnology is Atomic Force Microscopy (AFM). This instrument has become the most widely used tool for imaging, measuring and manipulating matter at the nanoscale. In the present project the student will learn,	ahmed.touhami@utb.edu

		manipulate, and practice the physics behind this sophisticated microscope. The student will also enhance his understanding on resonance, standing waves, simple harmonic motion, and light reflection.	
Dr. Ahmed Touhami	nanoscience/ nanotechnology **21**	**Optical Tweezers** Nanotechnology is going to significantly change our future. Some prognoses say that its impact on our lives will rival that brought about by the steam engine, electricity, the transistor, and the internet. One of the most important acronyms in nanotechnology is Optical Tweezers. This instrument has become the most widely used tool for measuring and manipulating forces and distances in many systems at the nanoscale level. In the present project the student will learn how light applies forces on tiny object like proteins and bacteria and how scientists utilize this sophisticated instrument to unravel the mechanisms of different biological phenomena. The student will enhance his understanding of optics, lasers, molecular forces, fields, and light reflection.	ahmed.touhami@utb.edu
Dr. Ahmed Touhami	nanoscience/ nanotechnology **22**	**Fluorescence Microscopy** The power and capability of the light microscope has increased dramatically over the last few years. This change has been driven by the need to study increasingly sophisticated problems at high spatial and temporal resolution. The advances, principally in the field of fluorescence microscopy have been dependant on the development of entirely new microscopic methodologies coupled to the use of fluorescent proteins, new fluorescent dye technologies, highly sensitive detectors and inexpensive powerful computers. In this project the student will learn the theory and principles of the high resolution light imaging, potential application and implementation of fluorescence imaging techniques, and more importantly, this will be couched in the real world application of biological experimentation.	ahmed.touhami@utb.edu