



# Undergraduate Research Symposium May 17, 2019 Mary Gates Hall

## Online Proceedings

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### SESSION 1I

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#### ROBOTS HUMAN SYSTEMS

*Session Moderator: Santosh Devasia, Mechanical Engineering*  
**MGH 248**

12:30 PM to 2:15 PM

\* Note: Titles in order of presentation.

##### **Mathematical Modeling and Design of a Robot Prototype**

*Abdulrahman (Abdu) Ghalib, Sophomore, Mechanical Engineering, AeroSpace Engineering, Lake Wash Tech Coll*  
*Samuel (Sam) Wolf, Sophomore, Computer Science, Mathematics, Lake Wash Tech Coll*  
*Geoffrey Powell Isom, Junior, Computer Engineering (Bothell)*

*Mentor: Narayani Choudhury, School of Science, Technology and Math, Lake Washington Institute of Technology, Kirkland*

Robotics combines machining and artificial intelligence to create real world humanoid models for task automation and industrial applications. We have designed an in-house robot prototype having microprocessor controlled motion. The robot has lasers for eyes and has a position sensor with camera attached. We designed the gear box, track assembly and robot parts and have written software to control the motion of the robot. The robot is good model for Roomba like vacuum cleaner. We create random walls using Monte Carlo simulations and used vector directed motion to control its motion for avoiding these random walls that the robot encounters to simulate real world experience. We have also studied robotic arm kinematics, using matrix algebra and trigonometry to help design a robot arm that we can rotate or translate to any point in three -dimensional space. We study both forward and reverse kinematics and have written software for the arm motion. Our studies provide an elegant educational platform for studies of robot motion along with simulating real-world experience.

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### SESSION 1L

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#### MATHEMATICAL MODELING IN THE SCIENCES

*Session Moderator: Elizabeth Thompson, Statistics*  
**MGH 271**

12:30 PM to 2:15 PM

\* Note: Titles in order of presentation.

##### **Mathematical Studies of Data Storage in CD-ROM and DNA**

*Iuliia Dmitrieva, Sophomore, Engineering Physics, Lake Wash Tech Coll*  
*Dylan Dean, Sophomore, Computer Engineering, Lake Wash Tech Coll*  
*Taylor Mills, Sophomore, Aeronautical Engineering, Lake Wash Tech Coll*  
*Mentor: Narayani Choudhury, School of Science, Technology and Math, Lake Washington Institute of Technology, Kirkland*

Current data storage elements have reached their threshold capabilities due to extensive data and limiting size requirements. Digital storage in DNA has aroused considerable interest as the next generation miniaturized high capacity storage device. Deoxyribonucleic acid (DNA) forms the genetic blueprint of life and is the primary carrier of genetic information in living cells and organisms. Data storage in DNA involves encoding of digital binary data into synthesized DNA strands. Here, we employ calculus-based methods to provide a comparative study of data storage capacities of conventional CD ROM and DNA. We use parametric equations to model the spiral structure in CD ROM and double helix of DNA and employ calculus-based methods to study the arc length, curvature and topological properties of DNA. The data storage densities for binary, base 3 and base 4 in DNA are estimated. The calculated data storage densities are found to be in good agreement with reported estimates. Recent studies demonstrate that magnetic nano-knots can be used for data storage. The topological properties of DNA including twists, links and knots thus provide additional attributes which may in future be used for data storage.

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## SESSION 1L

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### MATHEMATICAL MODELING IN THE SCIENCES

*Session Moderator: Elizabeth Thompson, Statistics*

**MGH 271**

*12:30 PM to 2:15 PM*

\* Note: Titles in order of presentation.

#### **Network Topology of Knots and Borromean Rings**

*Taylor Mills, Sophomore, Aeronautical Engineering, Lake  
Wash Tech Coll*

*Johnathan Hannon*

*Abdulrahman Ghalib*

*Mentor: Narayani Choudhury, School of Science,  
Technology and Math, Lake Washington Institute of  
Technology, Kirkland*

The use of magnetic nano-knots and Brunnian links for data storage and communications, makes understanding the geometric and network topology of knots and links very important. Recent reports suggest that DNA and other halogen networks self-assemble into exotic Borromean ring molecular topologies. Borromean rings form a Brunnian link with three rings linked in such a way that no two alone are connected. Only when all the three rings come together does the linkage occur. Borromean links form the current logo of the International Mathematical Union and they display strength in unity. Understanding knots, links and their networking is central to our understanding of DNA, protein folding, polymers and other soft materials. We have used a 3D printer to print and design a Borromean Math puzzle. The puzzle falls apart when a link is pulled out and is an excellent learning tool for studying Borromean link topologies. We use mathematical methods using parametric equations to study Borromean rings and trefoil knots. We wrote computer visualization code using SAGE to display trefoil knots and complex Borromean links for distorted circular, elliptical and other geometries. The SIEFERT surface of Borromean links are sketched using SeifertView and provide an aesthetic 3D view of the rings which can be oriented on a plane. The Seifert surface of a knot is a knot invariant; it is the characteristic of the knot with the knot as a boundary. The adjacency matrix and topological connectivity of the links are studied using vector directed graph models. A computer program is written to unravel the complex linking and intriguing connectivity properties of the trefoil knot and Borromean networks.