The purpose of the DX Demo – Mechatronics Bio-Tech Diagnostics Testbed is to be able to demonstrate bio-tech and diagnostic processes that are being researched and used in today’s medical field. The DX Demo – Testbed is a device that combines innovative biological processes to demonstrate the ability to rapidly decrease the time of accurate diagnosis. In the future, this product would be useful to analyze blood sample to assist medical professionals to diagnose and choose successful treatment plans. Currently, the goal of this project is to demonstrate how combining standard biology lab practices with automation can advance the medical field and improve the quality of healthcare. In order to achieve this, the design includes a collaboration of both mechanical and electrical based subsystems that will aid in demonstrating multiple complex bio-tech and diagnostic processes. The DX Demo – Testbed is a stepping stone towards what could be a game changer in the bio-medical field in years to come.

## Project Description

Through the combination of electronic and mechanical integration, known as mechatronics, a Testbed was created to demonstrate innovative bio-tech within the diagnostic field. The project includes 4 biological processes:

1. **Thermocycling**
   - Heating and cooling of a fluid is utilized for a biological process called Polymerase Chain Reaction (PCR).
2. **Sonication**
   - DNA sections can be quantified (or amplified) without degradation of RNA.
3. **Magnetic Separation**
   - Cells are used to identify pathogens during infections.
4. **Optical Examination**
   - Ultraviolet frequencies are used for a process called Cell Lysis.
5. **Optical Examination**
   - The intensity of the waves increases the permeability of biomolecular cell walls for entering contamination veins.
6. **Optical Examination**
   - Magnetic nanoparticles are created to bind to targets, so when an external magnetic field is applied separation of the molecular targets occur.
7. **Optical Examination**
   - Aids in separation of small molecules, proteins, tissues, organisms, and organelle materials, thereby having the potential to detect and measure bacterial, viral, and other pathogenic contamination.

### Biological Processes Explained

#### Thermocycling

1. The heating and cooling of a fluid is utilized for a biomedical process called Polymerase Chain Reaction (PCR).
2. DNA sections can be quantified (or amplified) without degradation of RNA.
3. Aids in detecting the presence or absence of a gene to help identify pathogens during infections.

#### Sonication

1. Ultrasonic frequencies are used for a process called Cell Lysis.
2. DNA sections can be quantified (or amplified) without degradation of RNA.
3. Aids in detecting the presence or absence of a gene to help identify pathogens during infections.

#### Magnetic Separation

1. Magnets are utilized in microfluidic：to locate desired molecular targets.
2. Magnetic nanoparticles are created to bind to targets, so when an external magnetic field is applied separation of the molecular targets occur.
3. Aids in separation of small molecules, proteins, tissues, organisms, and organelle materials, thereby having the potential to detect and measure bacterial, viral, and other pathogenic contamination.

#### Optical Examination

1. Optical photons are used to examine the way light interacts with biological substances.
2. When conditions of pathology (disease) are present, the absorption, scattering, fluorescence, amplitude, wavelength, and polarization properties of light passing through a biological sample often undergo significant changes that are measurable through optical examination.
3. Aids in non-invasive, non-invasive, high resolution, rapid-scan-time measurements determining healthy and diseased conditions at their earliest stages.

## The Fluid Flow

The fluid flow in the DX Demo – Testbed is the heart of the system and allows for the testbed to demonstrate and run the biological processes. To achieve this innovative way of fluid flow, a fill container (beginning point) and an emptying container (end point) were designed. These allow the system to run multiple demonstrations before the fluid needs to be refreshed. To move the fluid about the system, a syringe pump was designed to suction the fluid from the fill container and pump it through the cartridge into the emptying container. Lastly, in order to control the flow of the fluid from those points and through the tubing, solenoid valves were placed along the tubing, which direct sections of the flow path when needed. The top view of the testbed (left) displays all the fluid flow components (right) and the tubing pathways (highlighted yellow) the fluid passes through.

## The Cartridge and Bio-Tech Subsystems

The cartridge is a sensor that interprets light and is integrated with the laser diode system. As the laser light passes through the biological fluid within the flow path, the photodiode measures the change in the light and allows for the optical examination of the fluid.

## The Optical Transducer

The optical transducer is a device that can resonate at an ultrasonic frequency. The face of the transducer is flush against the cartridge, allowing the frequency to penetrate the cartridge layers into the biological fluid in the flow path. This subsystem allows for the biological process of cell lysis to take place.

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