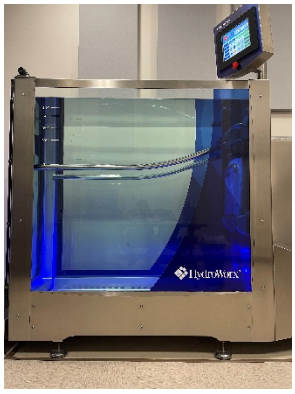
Movement Analysis Core Facility

The Core maintains the following laboratories contained in the 55,000 sq ft Biomechanics Research Building.

This includes:

1. Aquatic Therapy Lab, BRB 021
2. CAREN Virtual Reality Lab, BRB 027
3. Gait Lab, BRB 035
4. Bioinspired Robotics Lab, BRB 037
5. GRAIL Virtual Reality Lab, BRB 103
6. Main Gait Lab, BRB 116
7. Balance and Strength Lab, BRB 123
8. Brain Imaging Lab, BRB 129
9. Academic Lab, BRB 158
10. Computer Labs, BRB 224 and BRB 245

Aquatic Therapy Lab, BRB 021



This 246 ft^2 lab is dedicated to a self-contained underwater treadmill (300 series, HydroWorx, Middletown, PA, USA) that allows subjects to sit, stand, walk or run in an aquatic setting. This provides a buoyancy effect to offload lower limbs and drag to challenge the muscles in different rehabilitation protocols. EMG and triaxial accelerometry can be wirelessly recorded using 16 waterproof sensors (Mini Wave Waterproof, Cometa Systems, Bareggio, Italy). These sensors can transmit synchronously in humid or wet environments or asynchronously, with 8 hours of onboard data-logging, fully submerged using a custom remote controller.

CAREN Lab, BRB 027

This 1083 ft^2 lab houses a Computer Assisted Rehabilitation Environment (CAREN) (Motek, Amsterdam, Netherlands). It includes a 180-degree screen and front-mounted projectors for complete visual immersion. It uses 10 cameras (Vero, Vicon Motion Systems Ltd, Oxford, UK) for 3D motion tracking. The treadmill is a split-belt design with tracks for the left and right legs. Ground reaction forces are measured with six degrees-of-freedom (DoF) force platforms under each belt (MotekForce, Motek, Amsterdam, Netherlands). This treadmill is supported on a motion base that can translate and rotate about 6 DoF. The environment is controlled using D-Flow software and has several options for device integration.

Gait Lab, BRB 035

This 1335 ft^2 lab features five force platforms (Optima High Performance Series, AMTI Inc., Watertown, MA, USA) and a 12-camera motion capture system (Kestral 4200, Motion Analysis Corp, Rohnert Park, CA, USA). Force plates are embedded in a modular 3x4 array for many potential configurations. False plates are used to fill in extra spaces. The array is in-line with doubles doors to BRB 027 to allow for a 49 foot walking path.

This lab space also features an isokinetic dynamometer (Humac Norm, CSMi, Stoughton, MA, USA) to measure muscle strength and fatigue during a variety of exercises. The device has multiple attachments for testing lower and upper limbs motion across 22 standard test and exercise patterns. The dynamometer has adjustable range-of-motion stops so the attachments do not have to be changed when switching sides. The adjustable chair allows for comfortable prone and supine exercise testing and is made for easy rotational, positional, and inclination adjustments.

Insect Lab, BRB 037

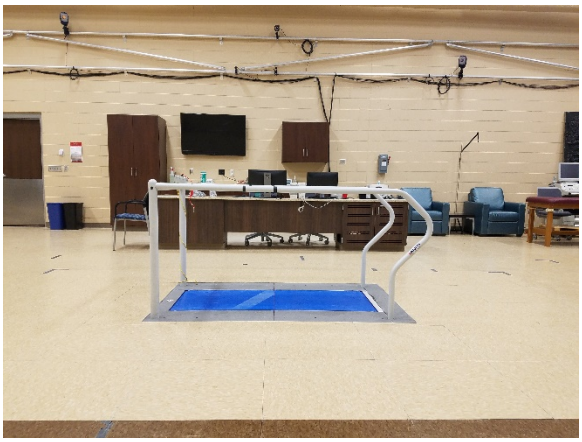
This 158 ft^2 lab is used for insect biomechanics. The climate-controlled room is maintained at 90 °F, was designed with escape barriers, and has an adjoining preparation and storage space. Insect movement is recorded in a custom made containment area using one TS5 and two IL5 high-speed digital cameras (Fastec, San Diego, CA, USA). These cameras can be used to record HD color or monochrome images. The TS5 can capture 2560 x 1440 images at 359 fps. The IL5 can capture similar images but while connected to a computer. Both models can collect images over 1000 fps can be mounted on a tripod or used as a handheld.

GRAIL Lab, BRB 103

The VR Lab is a 1,462 ft^2 space primarily featuring a Gait Real-time Analysis Interactive Lab (GRAIL) (Motek, Amsterdam, Netherlands). It is integrated with 14 cameras for 3D motion tracking, a high-definition video camera (Vero/Bonita, Vicon, Okford, UK), and an instrumented treadmill (Fully Instrumented Treadmill, Bertec Corp., Columbus, OH, USA). The treadmill is a split-belt design with tracks for the left and right legs. Forces are measured with six DoF force platforms under each belt as well as both handrails. The virtual environment is created by a front projection system and displated onto a 180-degree screen and floor with four projectors (one Optoma TX774 with 4000 lumens brightness and 2500:1 contrast ratio and three Barco F50s with 5000 lumens and 5300:1 contrast ratio). Virtual environments can be created in-house using Computer Aided Design (CAD) software or obtained from Motek. The system includes an A/D board and mechanical relay box (Phidgets Inc, Calgary, Canada) to interface the GRAIL with other systems.

Portable equipment used primarily in this lab includes two actuator units and four different end effectors (Humotech, Pittsburgh, PA, USA). The actuator units use MATLAB and SIMULINK (MathWorks, Natick, MA, USA) to control the end effectors. These effectors include an ankle prosthesis, two ankle exoskeletons, hip exoskeleton and a harness. The system can integrate data from our instrumented treadmills and wired EMG systems for use in the effector's control algorithms.

Main Gait Lab, BRB 116



This 2,535 ft^2 lab features 14 cameras for 3-D motion capture (Raptor/Kestrel 4200, Motion Analysis Corporation, Rohnert Park, CA, USA) and a 60 ft walkway with fall-arrest support. There are 8 embedded force platforms (Optima/Gen5, AMTI, Watertown, MA, USA) and a tandem-belt instrumented treadmill (Force-Sensing Tandem Treadmill, AMTI, Watertown, MA, USA) with 6 DoF force measurement capabilities. A dedicated 16 sensor EMG system (Trigno Avanti, Delsys Incorporated, Boston, MA, USA) is integrated to this space. It also has two 4K cameras (LUMIX BGH1 Cinema 4K, Panasonic, Moriguchi, Osaka, Japan) that are positioned to record sagittal and frontal plane video.

This lab also includes a treadmill that measures foot pressure (KinTread Pressure Treadmill, Noraxon U.S.A. Inc., Scottsdale, AZ, USA) to analyze force and pressure distribution during standing, walking, and running. There is a 10 camera motion capture system with 2 high-speed cameras (OQUS 500/Miqus, Qualisys, Göteborg, Sweden) is housed in this lab as well. This camera system is dedicated to sports biomechanics and includes golf and baseball analysis modules from the manufacturer.

Portable equipment used primarily in this lab includes:

A 4 ft by 20 ft instrumented walkway (Zeno Electronic Walkway, ZenoMetrics LLC, Peekskill, NY, USA) that measures spatial and temporal characteristics of walking without any on-body instrumentation.

A stairway with three integrated platforms and handrails for force measurement (Instrumented Stairs, Bertec, Columbus, OH, USA). It can be readily integrated with motion capture systems to allow four continuous steps during stair ascent and descent, three of which with complete kinetic and kinematic measurements. This system is mounted on adjustable casters that allow it to be moved and can be raised to fix it in place.

An imaging ultrasound (LS 128 CEXT, Telemed, Milan, Italy) can be used to image muscle activity in real-time during gait or other activities. It can also be synchronized with any of our motion capture systems.

Balance and Strength Lab, BRB 123

The Balance and Strength Lab (548 ft^2) primarily features two independent systems:

1) A device that provides an objective assessment of balance control and postural stability under dynamic test conditions through the use of computerized dynamic posturography and immersive virtual environments (CDP/IVR, Bertec, Columbus, OH, USA). The unit provides assessment and retraining capabilities on a static or dynamic support surface and in a stable or dynamic visual environment. The immersive virtual environment can be changed using real-time adjustable parameters. The device features assessment and treatment protocols and the ability to create custom protocols. A unique feature of the unit is that it has a low step-up profile, which provides easy access for patients that have balance problems and are more susceptible to trips and falls.

2) A dynamometer (System 4, Biodex, Shirley, NY, USA) that can measure strength and fatigue during a variety of exercises. It comes with multiple attachments for the dynamometers to accommodate exercises involving the limbs and torso. It also includes a chair with several positioning, rotation and inclination adjustments.

Brain Imaging Lab, BRB 129

This 178 ft^2 space houses equipment used for noise-sensitive brain imaging and features an airlock and concrete walls for noise cancellation. The 24 Channel Optical Topography System (ETG-4000, Hitachi Medical Systems, Tokyo, Japan) is an FDA approved device that enables imaging of the cerebral cortex during sitting or standing using infrared technology. This lab houses two electroencephalograms (EEG). One is a 128-channel system (System 400, Electrical Geodesics Inc., Eugene, OR, USA). The system is integrated with E-Prime software (Psychology Software Tools, Sharpsburg, PA, USA) and peripheral sensors including: EKG, oximeter, airflow sensors and polygraph. It installed on a wooden desk with casters for electrical isolation and portability. The other EEG system is ANT Neuro (eego mylab, ANT Neuro, Hengelo, Netherlands). Both measure the electrical activity in the brain. It uses a net of 130 electrodes wrapped around the scalp and face. This space is also equipped with an 8-camera motion capture system (Impulse X2, PhaseSpace, San Leandro, CA, USA) that has a maximum capture rate of 960 Hz.

Portable equipment used primarily in this lab includes:

A functional Near-InfraRed Spectroscopy (fNIRS) (NIRSport 2, NIRx, Berlin, Germany) that measures hemodynamic responses to neuroactivation via oxy-, deoxy-, and total hemoglobin changes in the cerebral cortex.

Teaching Lab, BRB 158

This 294 ft^2 lab features an 8 camera motion capture system (T160, Vicon Motion Systems, Oxford, UK). It is integrated with 4 strain gage force platforms (OR6-7-OP Force Platform, AMTI, Watertown, MA, USA). This space is used primarily for the education of undergraduate and graduate students.

Computer Labs, BRB 224 and BRB 245

These areas contain 24 computers that are available for processing data. Applications that are the computers in these labs include:

- Cortex (Motion Analysis Corporation, Rohnert Park, CA, USA)
- D-Flow (Motek, Amsterdam, Netherlands)
- MATLAB (MathWorks, Natick, MA, USA)
- Nexus (Vicon, Okford, UK)
- Qualisys Track Manager (Qualisys, Göteborg, Sweden)
- ResearchIR (FLIR, Wilsonville, OR, USA)
- SPSS (IBM, Armonk, NY, USA)
- Visual3D (C-Motion, Germantown, MD, USA)

Portable Equipment

The Biomechanics Research Building houses numerous equipment that is used in multiple labs and is not assigned to any particular space.

Metabolics

1) A metabolic cart (TrueOne 2400 Metabolic Measurement System, ParvoMedics, Sandy, UT, USA) used to measure intrapulmonary gas exchange analysis during stationary studies, such as running on a treadmill or pedaling on a stationary bicycle. It can provide an accurate measure of pulmonary gas exchange, i.e. VO2, VCO2, Ventilation, energy expenditure, etc.

2) We have two portable metabolic carts (Cosmed K5, Cosmed USA Inc., Chicago, IL, USA) available for use. It can provide breath-by-breath analysis and is can be used in non-stationary studies.

Electromyography (EMG)

Two EMG systems (Trigno Avanti, Delsys Incorporated, Boston, MA, USA) together have 24 Trigno Avanti and 24 Trigno wireless sensors that can be freely paired with installed software on desktops, laptops and mobile devices. Each Avanti sensor includes one EMG channel and a full IMU for a total of 10 channels per sensor. Each base Trigno sensor includes one EMG channel and one tri-axial accelerometer. Data from these sensors can be recorded directly through Delsys EMGWorks software, with motion capture systems. Synchronization is allowed with an additional Delsys Trigger Module

Eyetracking

A head-mounted eye tracker (Glasses 2, Tobii, Stockholm, Sweden) that samples gaze data at 100 Hz. It simultaneously records video from a front-mounted camera and has interchangeable corrective lenses. It can both send and receive event signals.

Inertial Motion Capture

1) Two motion capture systems (Awinda, XSENS, Enshede, Netherlands) allow joint angles to be recorded. They use markerless technology based on inertial measurement units to record movement. They can be used inside and outside the lab and be synchronized with other equipment.

2) A motion capture system (Opal, APDM, Portland, OR) that can measure kinematics. It can also be synchronized with other systems using TTL signals.

Software

Various applications are available for analysis and design:

- **ActiLife** (Actigraph, Pensacola, FL, USA)
- **Arduino IDE** (Android Studio (Mountain View, CA, USA)
- **Autodesk Suite** (Autodesk, Inc., San Rafael, CA, USA)
- **Cortex** (Motion Analysis Corporation, Rohnert Park, CA, USA)
- **D-Flow** (Motek, Amsterdam, Netherlands)
- **EMGWorks** (Delsys Incorporated, Boston, MA, USA)
- **EMG & motion tools** (Cometa srl., Bareggio, Italy)
- **LabVIEW** (National Instruments, Austin, TX, USA)
- **MATLAB** (MathWorks, Natick, MA, USA)
- **MR3** (Noraxon, Scottsdale, AZ, USA)
- **MVN** (Xsens, Enshede, Netherlands)
- **Nexus** (Vicon, Okford, UK)
- **Prism** (GraphPad Software, San Diego, CA, USA)
- **Qualisys Track Manager** (Qualisys, Göteborg, Sweden)
- **SolidWorks** (Dassault Systems, Vélizy-Villacoublay, France)
- **SPSS** (IBM, Armonk, NY, USA)
- **Unity** (Unity Technologies, San Francisco, CA)
- **Visual3D** (C-Motion, Germantown, MD, USA)