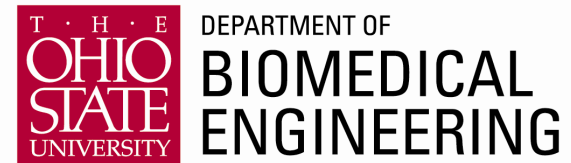


# ME 4905

## Engineering Design for Biomedical Applications

Sandra Metzler, D.Sc., PE  
Mechanical Engineering  
metzler.136@osu.edu

*Department of*  
**Mechanical and  
Aerospace Engineering**



# ME 4905

## Course Structure

### Students:

- 25 - 30 ME students
- 75 BME students
- Groups consist of 2-3 students from each discipline

### Mentors/team advisors:

- Engineering mentor from ME or BME
- Clinical mentor from Occupational therapy, Physical therapy, Sports Medicine, Surgery, Nursing...

# ME 4905

## Course sequence

### Fall:

- Second seven weeks:  
ME 4905.01 'Capstone Design – Assistive Devices'

### Spring

- ME 4905.02 – 'Capstone Design III – Assistive Devices'
- Fully integrated BME/ME/CSE teams

## Course goals and workflow

- Students work on a multi-disciplinary team to develop a user-focused medical device
- Workflow mimics an engineering design department
- Students will design-build-test a medical device over the course of two semesters
- Students will build a comprehensive device portfolio over the course of the two semesters
- Students will gain experience in technical communication and presentation skills in addition to project management

## The Assistive Technology (AT) Center



## The Assistive Technology (AT) Center





# Recent Projects

## Pressure and force measurement for Physical Therapy

### Background

Physical therapy is taught in an apprenticeship manner that poses difficulties in standardizing care from one physical therapist to another. The teaching of manual therapy manipulations is especially dependent on qualitative, rather than quantitative, feedback.



Figure 1: Spinal manipulation during manual therapy [2]



Figure 2: Spinal manipulation during manual therapy [2]

The structure of the segments of the spine



Figure 3: Anatomical diagram of the spine [3]

Similar devices also use force sensing technology to determine the forces exerted by the hand, but they are either too expensive, may provide discomfort to the patient, or do not allow for the range of forces that are typically applied during a PT session.



Figure 4: TactileGlove created by PRR [4]

### The Design and Prototype

Component	Function
1. Velostat Sheet	Conductive layer with modular resistance based on pressure applied, allows force measurement
2. Vinyl Casing	Insulates circuit components on the surface of the hand
3. Arduino	Force data acquisition and data transmission via Bluetooth
4. Raspberry Pi 3 B+	Receives force data via Bluetooth link and displays on portable 7" touchscreen
5. Battery Box	Houses the device's power source and circuit board



# Recent Projects

## Paracycling service station

### Background

Paracycling is a sport that interests many individuals with cognitive and physical disabilities and allows them to continue to be outside and stay active. The increase in interest comes with the need to increase the accessibility of the activity to all involved in both participating and servicing their equipment.



Emilie Miller, world champion paracyclist.



Traditional Recumbent Bike Stand

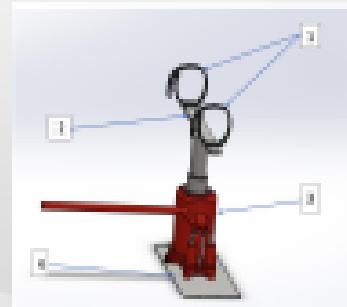


Traditional Upright Bike Stand

Thus, came the need for a service station that enabled all participants, regardless of their disability, the option to perform and participate in the serving of their own bikes. With the unique - and often awkward - shape of the recumbent bikes and hand cycles, a unique service station needed to be created to allow all participants and users the ability to readily service their own bikes out in the field.

### The Design and Prototype

Label	Feature	Function
1	Cinches	Secure the bike when lifted
2	Top Bar	Supports the weight of the bike
3	Hydraulic Jack	Lift the bike up when necessary
4	Base	Stabilizes the service station when used





# Recent Projects

## Patient warming device for ICU use

### Background

Hypothermia is a common issue faced by patients in the ICU, but it can be deadly. It is defined as the drop in body temperature below 95°F. The warming device created will mainly be used for trauma and postoperative patients who are hypothermic and at risk of developing the lethal triad – a combination of hypothermia, acidosis, and coagulation that can cause a patient's condition to rapidly deteriorate.

*Current device used in hospitals:*  
3M Bair Hugger

#### Problems:

- Not flexible (hard to access patient)
- Bulky (not easily moved)
- Difficult to set up quickly
- Easily displaced from under patients



Fig. 1. 3M Bair Hugger

### The Design and Prototype

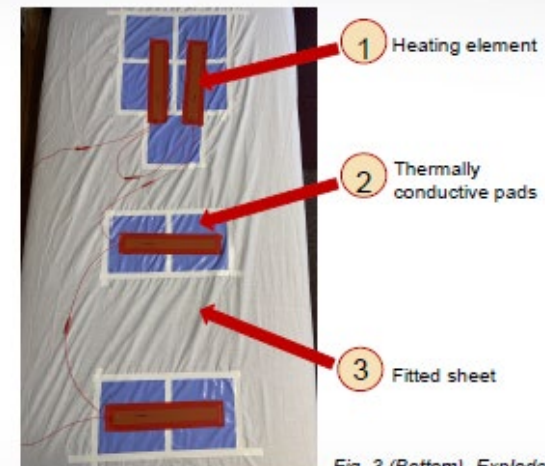
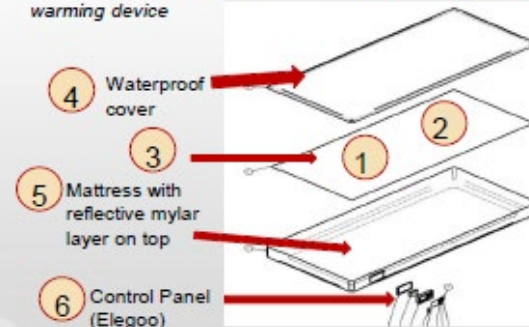


Fig. 2 (Top). Underside of warming device

Fig. 3 (Bottom). Exploded view of warming device



# Recent Projects

## Portable ventilator for low resource environments

### BACKGROUND & AIM

#### BACKGROUND

##### Mechanical Ventilators

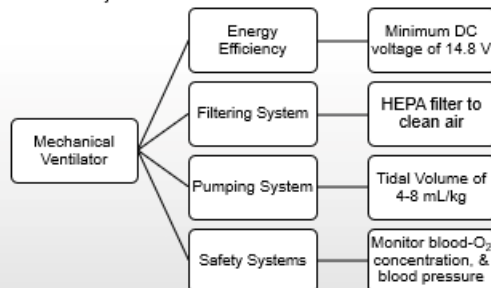
- Provide life-sustaining breath to patients in respiratory failure
- Primary concern: Barotrauma (pressure related trauma on lungs)
- Expensive & Complex
  - Disasters → Total electrical power failures of modern ICU units
  - Healthcare workers must use Bag Valve Mask (BVM) ventilation
- Pandemics have huge financial expenses
- COVID-19: attacks respiratory system
  - Univ. of Nebraska Medical Center: 960,000 people will need ventilatory support
  - United States: 200,000 hospital-based ventilators available
- Currently there are no commercial low-cost ventilators that can operate without an electrical grid connection.

#### AIM

- Create a low-cost mechanical ventilator to be used outside typical hospital setting.
- This would extremely useful during a global pandemic or other emergency situations, disasters.

### SCOPE & REQUIREMENTS

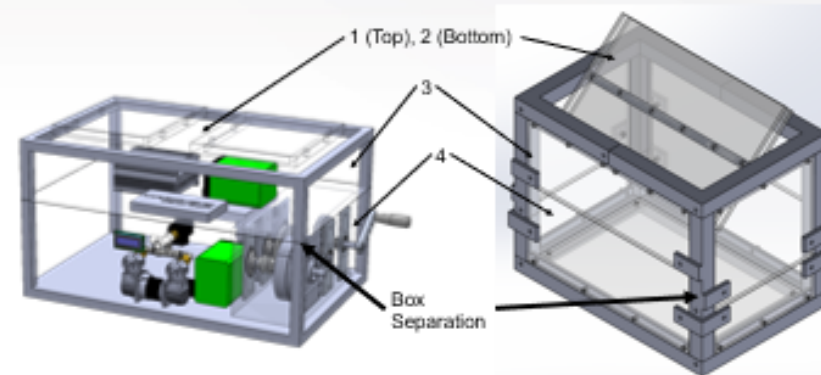
- Proposed mechanical ventilation design must be easily obtainable, and easy-to-use for hospitals and health care providers in natural disaster-stricken areas.
- Constraints could include cost-of-device, time-to-assemble, size/weight, and local renewable energy source.
- The success is directly related to the amount of sustainable energy generated and consumed by the ventilator.



### DESIGN & PROTOTYPE

#### 4-LEVEL MODULAR BOX DESIGN

- (1) Exterior Top: Solar Panel for energy absorption
- (2) Interior Top: Electrical Housing and Conversion of Solar Energy to Electrical
- (3) Interior Middle: Ventilator Body in between two layers of shaped foam protection
- (4) Interior Bottom: Oxygen Compressors, Battery Storage, Necessary Pneumatic components, Mechanical Crank for energy absorption



#### DEVICE DISPLAY

- Display mockup through Android Studio
- Completed display will be on a Raspberry Pi with touch screen capabilities.
- (5) Ventilator data in graph format
- (6) Enlarged data values
- (7) Device battery percentage and time to empty
- (8) Ventilator controls

# ME 4905

## Unique features & benefits

- Each group has an engineering advisor and a clinical/medical advisor.
- Opportunity to work in a medical environment on current real-world problems.
- Products are tested in the clinic with medical professionals and patients.
- Many of the designs are incorporated into the clinical setting during or after the course.
- Make a difference while learning the process of design!

# ME 4905

How to register?

Sign up for ME 4905.01

No need to email me or get permission

First come, first registered!

# Questions?

Dr. Sandra Metzler

Scott Lab W292

Email: Metzler.136@osu.edu