IPRO 319: New Technology for Cardiac Arrest Victims

Presenters: Grant Austin and Jennifer John

Presentation Outline

- Introduction
- Goals
- Team Structure
- Timeline
- Results
- Obstacles
- Future Challenges
- Conclusion

Cardiac Arrest

- Disruption of heart activity
- In the US,
  - 265,000 cardiac arrests outside hospitals
  - 18% survival rate after discharge in hospitals
  - 95% of victims die before reaching hospital
- Induced hypothermia reduces neurological damage
- Z-axis oscillation along the spine, shown to be better than normal CPR

Previous Work

- Spring 2006: Oscillator for testing mice
- Fall 2006: Developed oscillation table for U of C
- Spring 2007: Basic cooling jacket model
- Spring 2008: Cooling jacket
- Fall 2008: Reduced oxygen breathing mask
- Spring 2009: Investigated chemical cooling and effects of oscillation
- Fall 2009: Designed and constructed oscillator and cooling bed prototypes

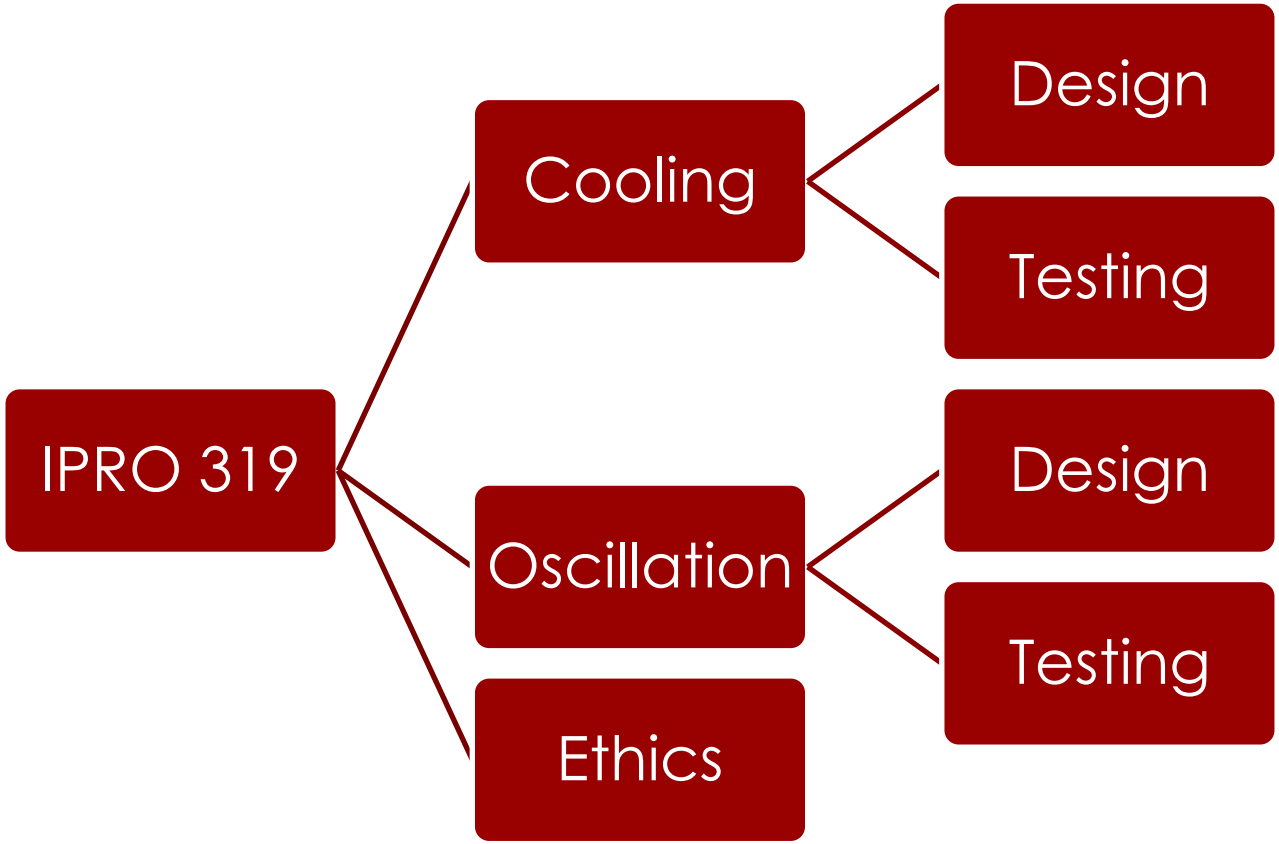
Project Goals

- Develop and investigate two devices:
  - rapid cooling bed/blanket
  - periodic z-axis accelerator

Mission Statement

- *Develop and improve upon cooling and oscillation technologies*

Team Structure

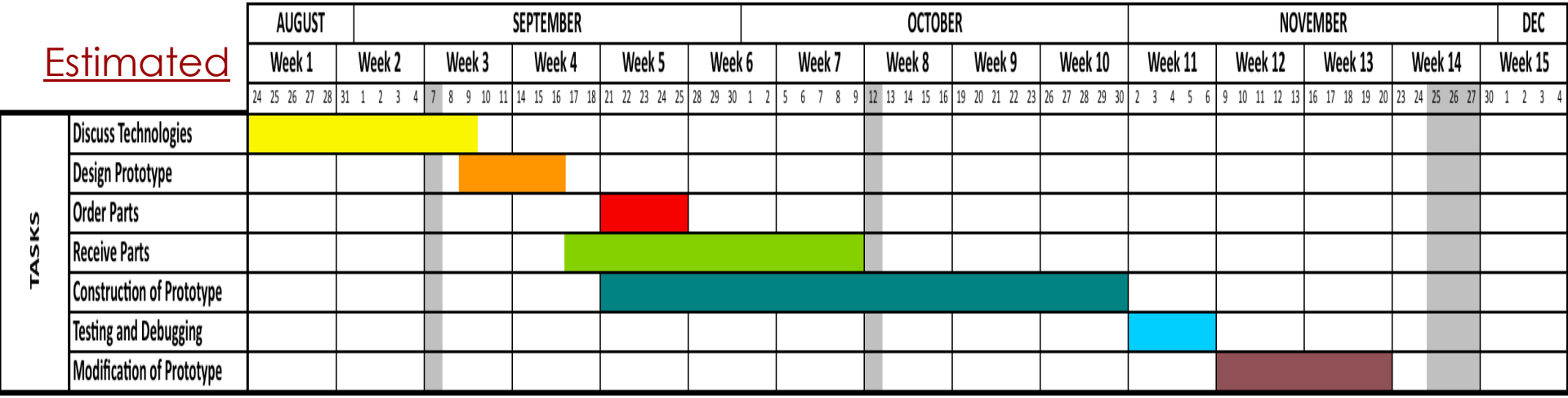


Team Development and Performance

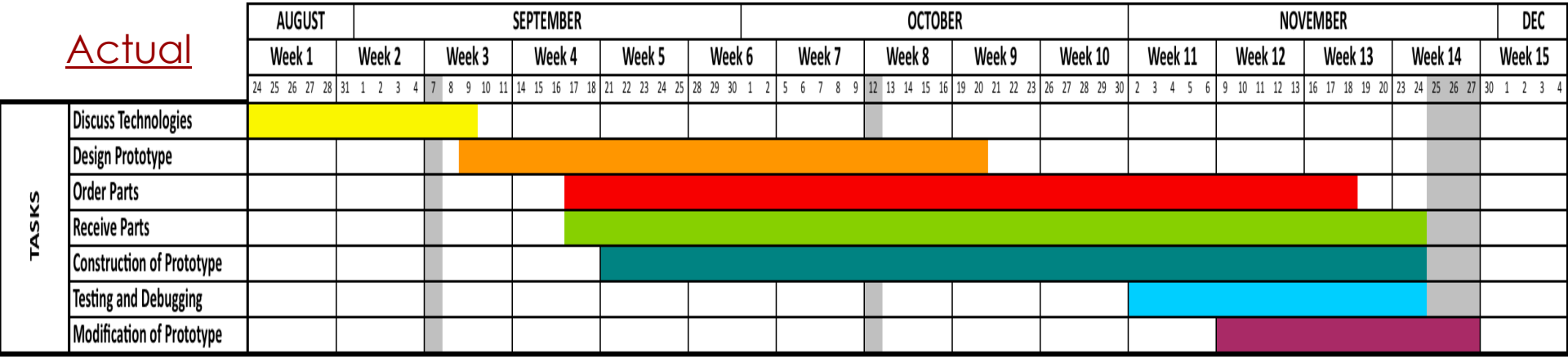
- Learning how to work together
  - Helping other subgroups in areas each individual member has expertise
- Continuously challenging one another
  - Weekly presentations of progress
  - Intense brainstorming and Q&A sessions
- Developing communication skills

Timelines of Progress

Estimated



Actual

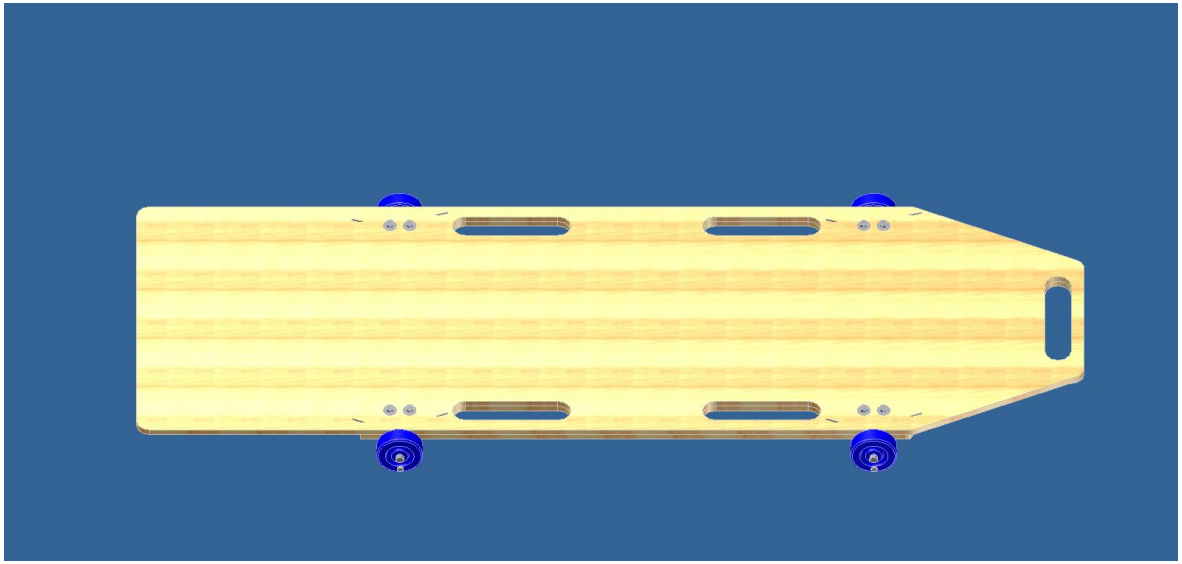


Shaking Table Design

- Force per wheel is:

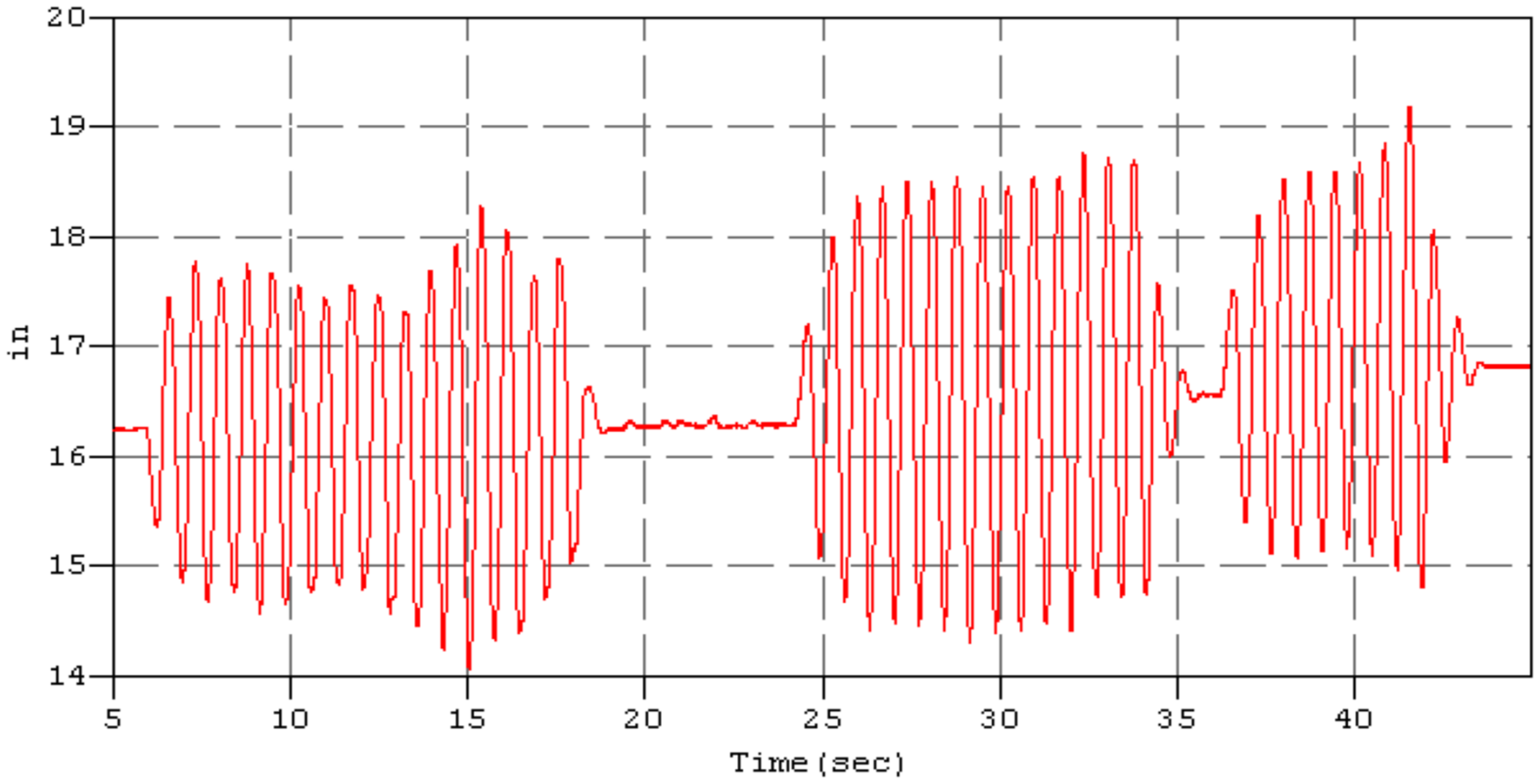
  Flin=macrit=(100kg)*(5.884m/s²)= 161.81N.

- Thus, 4 wheels of radius 3 ½" with springs each with spring rating of 34.290 lbf-in.



Shaking Table Results

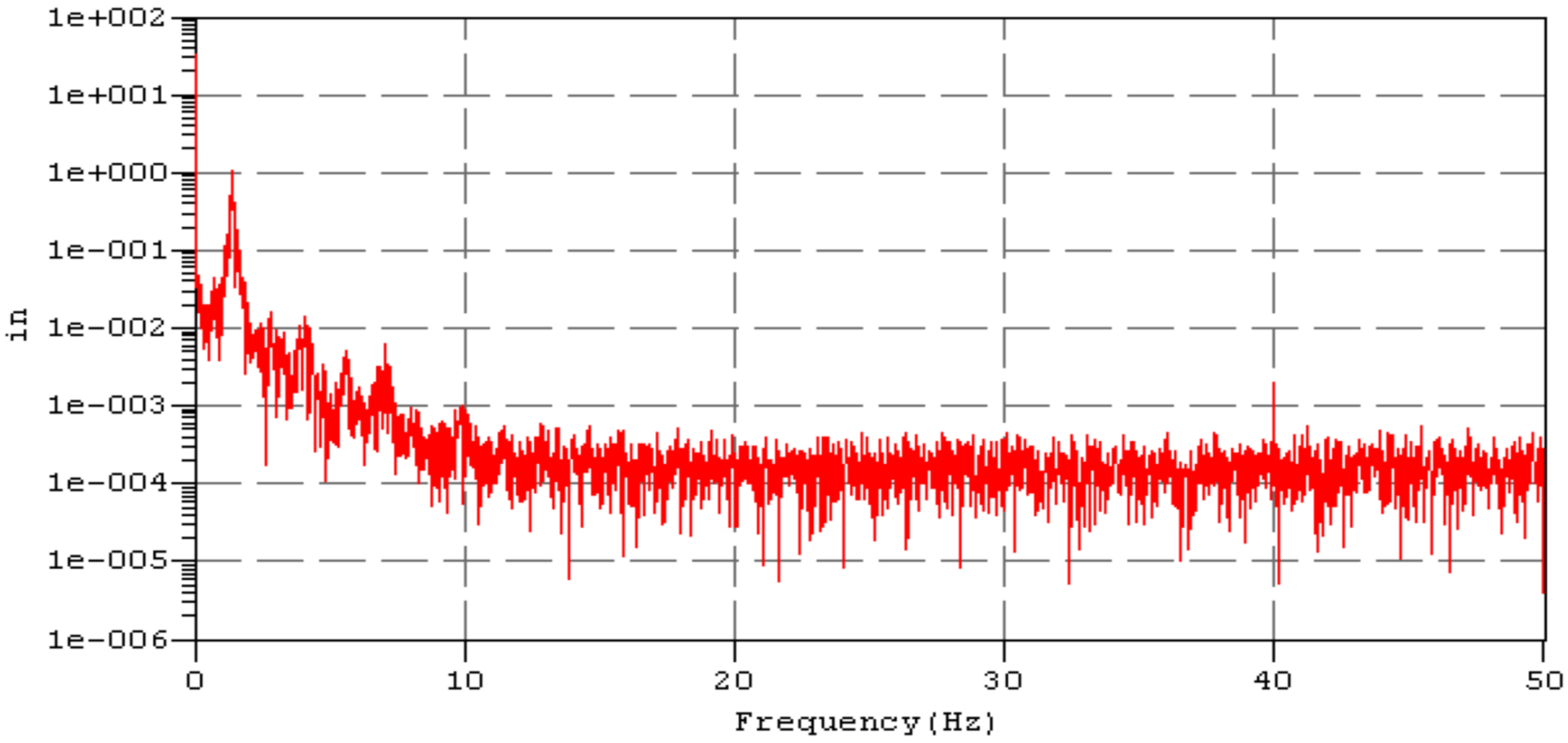
Linear Displacement vs. Time (sec)



Shaking Table Results

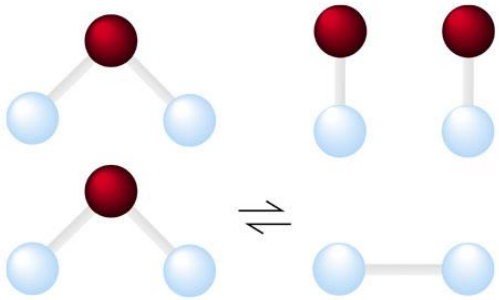
Auto (Power) Spectrum

$k_{theoretical} = 9771 \frac{N}{m}$ $k_{experimental} = 8720 \frac{N}{m}$ $\frac{8720 \frac{N}{m}}{9771 \frac{N}{m}} = 89.2\%$



Cooling Design

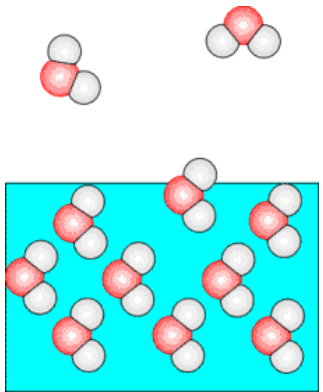
- Chemical Reaction vs. Phase Change
- <u>Ammonium Nitrate and Water:</u>



$$Ba(OH)_2 \cdot 8H_2O_{(s)} + 2NH_4NO_{3(s)} \longrightarrow Ba(NO_3)_{2(s)} + 2NH_{3(aq)} + 10H_2O_{(l)}$$

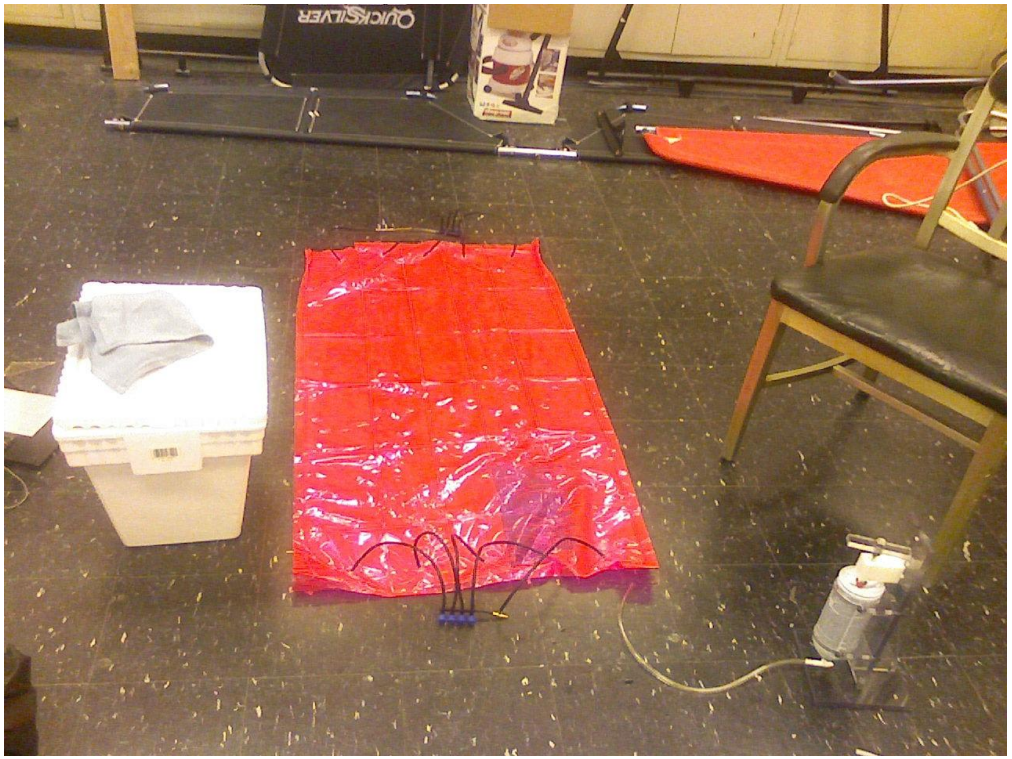
- Cooling Capacity: **197.4 kJ/kg**

- <u>Phase Change</u>: R125a
- Cooling Capacity (from EES software): **238.5 kJ/kg**

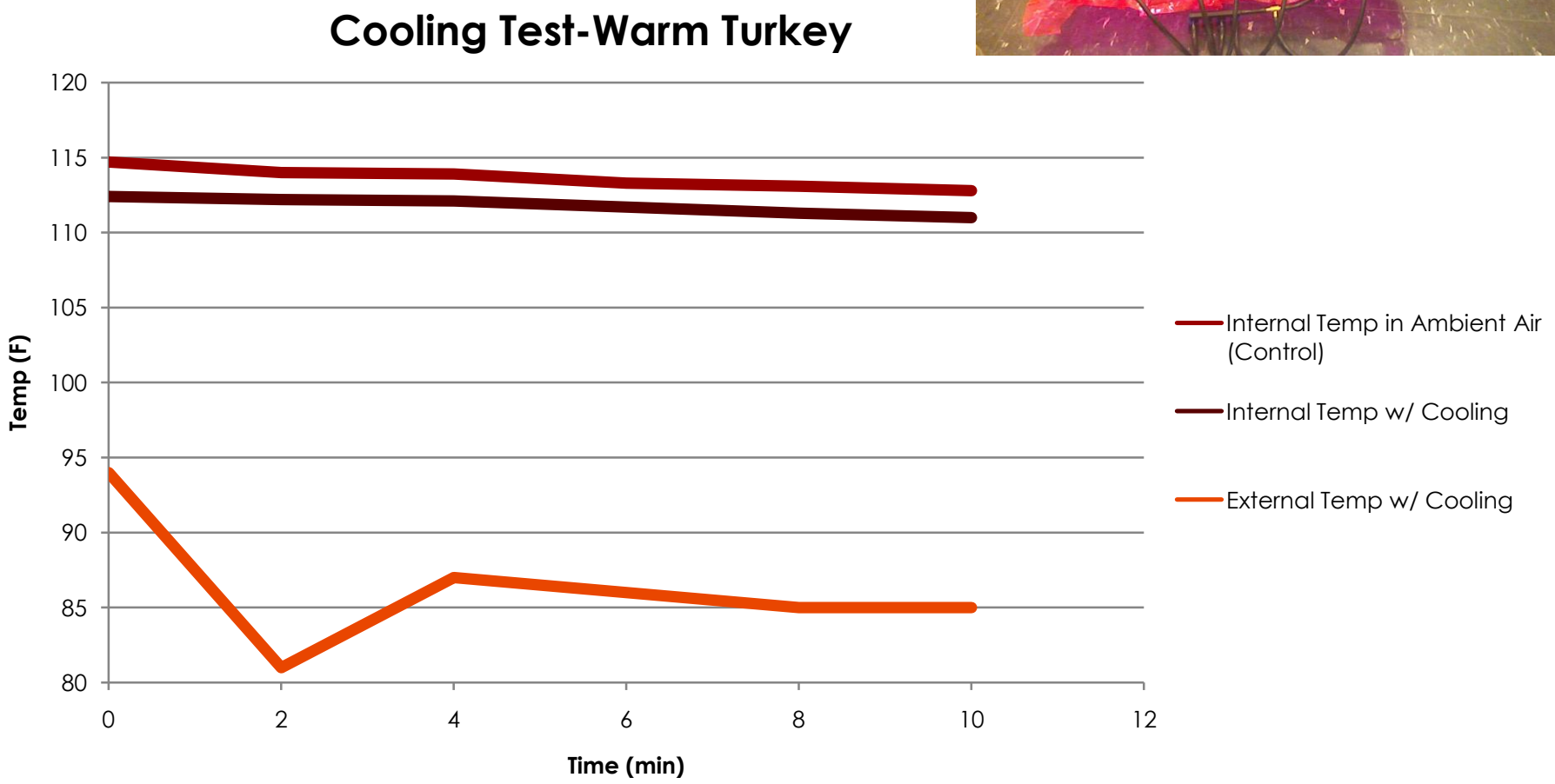


Cooling Design

- Found a suitable material
  - Manipulated via heat sealer
- Tube system to channel refrigerant throughout bed
- Developed pop-rivet/washer valve mechanism to simplify tube attachment
- Custom refrigerant holder optimized ease of use
- Testing the bed alone proved the cooling surface reached temps of -15 F



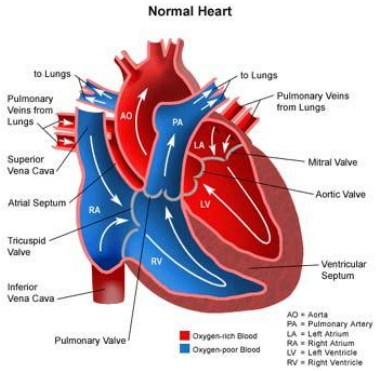
Cooling Results



Obstacles

- Designing devices that the average person would feel comfortable using

- Time & money
- Developing accurate mathematical models
- Constructing an accurate model prior to living subject testing
  - One-way valves?
  - Connecting the heart to system?
- Implementation of devices

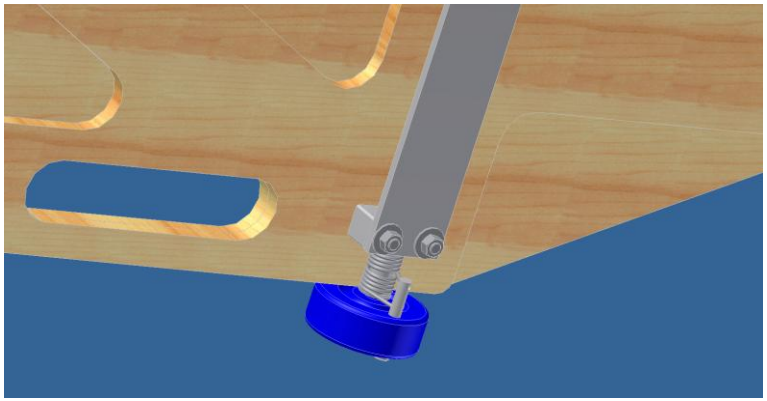


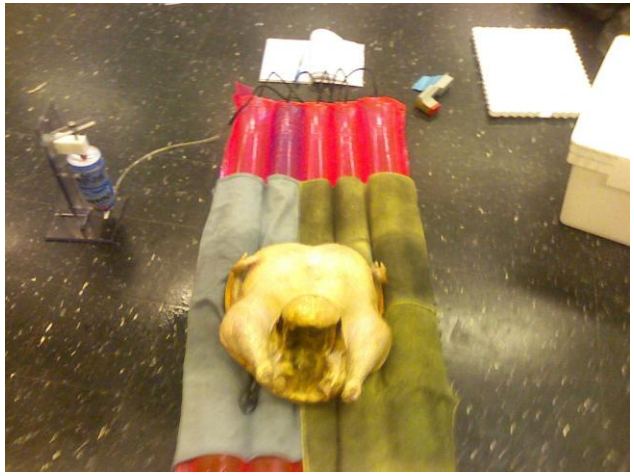
Ethical Issues

- Testing on Humans
- Making a decision for a victim that could be physically damaging
  - Negative effects of shaking
- Documents of Interest
  - Universal Declaration of Human Rights
  - Nuremberg Code
  - Belmont Report
  - International Ethical Guidelines for Biomedical research involving human subjects
  - Public Act 096-078

Achievements

- Successfully created two working prototypes: one for cooling and one for oscillation
- Tested prototypes: cooling on a body-temperature turkey and acceleration with human weight
- Learned to manage tasks in parallel to contribute to more than one subgroup





Recommendations

- Cooling:
  - Thinner bed for better evaporation/skin interface
  - Gel conducting material
  - Better refrigerant containment system
- Oscillation:
  - Refine design of full-scale model
  - Animal and human testing
  - Increase stability of subject
- Overall:
  - Revising EMS protocol to adapt new technology

Questions?

Special thanks to Francisco Ruiz,
Ray DeBoth and the IPRO Office