1. Objective:
IPRO 332 begins an investigation of the use of mechanical shaker beds in a life-support capacity for beings with cardiac arrest. It will develop and continue research that was begun at the Miami Heart Research Institute, and will work in conjunction with researchers at IIT and the University of Chicago. There are two primary objectives for the semester:

1) Design and construct a controllable shaker bed for mice, based on specifications from IIT and University of Chicago researchers.
2) Investigate the implementation of shaker bed technology as a medical device for humans, including but not limited to: practical, ethical, and legal feasibility.

2. Background
Several years ago researchers discovered that it was possible to keep a pig after its heart had been stopped by placing it upon a vibrating platform. After being on the platform for up to 20 minutes, the pig's heart could be restarted (for example with a defibrillator) and it would resume completely normal biological functioning. Essentially it replicates the process of cardiopulmonary resuscitation (CPR). The physical mechanism behind this effect, as produced by periodic acceleration (i.e. "shaking"), is under investigation.

To that end, researchers at IIT and the University of Chicago are conducting similar research on mice. IPRO 332 will assist their research by developing the mechanical device to shake the subject. The IPRO will also investigate the scaling and adaptation of this technology to potentially be used by emergency medical personnel.

In developing the shaker bed for mice, the team must receive the operational requirements for using periodic acceleration CPR on the murine scale. From this information, the team will design the shaking apparatus and the device used to affix the mouse to the bed, utilizing either rotary or a linear motor to drive either a mechanical or hybrid mechanical-electrical mechanism that will "shake" the specimen. The device will be designed to minimize complexity and cost. Once the design is completed, parts will be ordered and the device will be assembled. The anticipated problems primarily involve designing and constructing the device in such a way that both the frequency and the amplitude of the oscillations can be precisely controlled in real-time. Once completed, the device and its plans will be turned over to the researchers at the University of Chicago.

Investigating the adaptation of shaker bed technology for medical use with humans will require a substantial amount of research. The proper scaling of the required amplitude and frequency of oscillation must be investigated, and then a design can be created based on the one for shaking mice. In the meantime, the team will investigate any ethical, moral, cultural or scientific issues that may be involved in the testing of this technology, and its eventual use with humans, through internet and library research. Sponsors and potential customers will be queried as time permits in order to ascertain the business or societal costs of this technology.

3. Methodology

IPRO 332 has been tasked with developing a mechanical shaker bed for use in researching periodic acceleration as a viable form of CPR on murine subjects, i.e. mice and similar mammals. It must design, construct, and test the entire mechanism, with the end result being a compact, reliable, practical device that allows a researcher to control the frequency and amplitude of the oscillation in real-time. It must restrain the subject effectively without restricting respiration or circulation or causing any other significant injury, and must allow the other necessary equipment, such as oxygen masks and medical sensors, to remain affixed to the subject for its entire duration on the shaking bed. It should also be as inexpensive as possible while still meeting the performance guidelines defined by the researchers.

Meanwhile, the IPRO will also investigate the adaptation of the technology for use with human subjects. This will encompass both research into the moral, ethical, and legal issues surrounding both testing and implementation, and creating a preliminary design of such a device. To that end, a significant amount of research must be done to learn about laws and precedents governing the testing of new medical technology, including but not limited to: applicable patents/patent law, verification that a prototype is fit for use in real human subjects, the process for testing a new device on humans and the surrounding legalities, what redundancies must be in place in the event that the CPR fails, etc. Once the team has a solid understanding of this, a reference guide or database of such information will be created for future use. The team will then use the design of the mouse shaker bed to design a similar device for humans, including engineering calculations and schematics. As time permits, sponsors and potential customers will be queried.

In order to accomplish these tasks, the team split into two main subteams: one to design the mouse shaker bed and one to investigate the human angle. They will work concurrently, and their tasks are delineated as follows:

<u>Mouse Team</u>

a. Network with Harshbir Sidhu, IIT graduate student, to discuss the specifications of the mouse shaker bed, particularly the optimum frequency and amplitude of the oscillation based on his calculations, as well as the desired range for these parameters that the machine should be capable of functioning at.
b. Create a preliminary design of the device. This includes deciding on the mechanism to shake the platform, devising a method to adjust the frequency and amplitude of the shaking in real time, ideally continuously (rather than between specific preset values), and creating a device to restrain the subject while the bed is shaking. Calculations for the requirements of the motor and other components must be conducted as well. Schematics should be created and properly dimensioned in a CAD program.
c. Finalize the design and select the parts to be used. The team must complete a design that will be approved by the IPRO Advisor and the researchers. It must then locate and purchase the components that will be used in the machine.
d. Assemble the device.

e. Test and troubleshoot the device. This stage will likely take the most time. Sensors will be affixed to the bed and wheel so that the precision of the controls can be examined and corrected. A rubber mouse or murine cadaver will be used as a test subject to ensure that it remains on the bed and does indeed experience the intended oscillation parameters. The data should be logged by hand, based on readouts from the electronic instruments. The readouts of the actual sensors will be compared to the theoretical results from the calculations, and to the settings of the controls, using Excel or a similar program to measure the correlations. When the device operates with what the team believes is acceptable precision and accuracy, the results will be compiled into a report by the team to be handed to the researchers. If they are satisfied, the device and plans will be turned over to them as well; if not, further testing and modification will follow.

Human Team

a. Network with Harshbir Sidhu, IIT graduate student, to discuss the specifications, particularly the optimum frequency and amplitude of the oscillation based on his calculations. In particular, the parameters must be properly scaled to human-sized subjects.
b. Research laws and government regulations regarding new medical technology. Government websites and library references should provide a good source of such information. Relevant points should be documented and summarized.
c. Investigate laws, regulations, and procedures specifically regarding the testing of medical technology to be used on humans. The findings should be documented, indexed, and summarized for future reference.
d. Once the mouse team's design is finalized, a similar design will be created for use with humans. Engineering calculations must be done to incorporate the necessary parameters for successfully performing CPR on humans via periodic oscillation, as well as to ensure that the design can accommodate the significantly higher mass of the human (relative to the mouse). Schematics of the design should be created in a CAD program and properly dimensioned. If possible, computer simulations of the design should be performed.

To complete the IPRO Midterm Report, each team member will submit personal results to be compiled into a document by a responsible delegate. The last week before IPRO Day will be dedicated to creating the presentation and booth, which will be a completely collaborative effort involving all members of the team.

One student will be responsible for creating and maintaining the website with updates of the team's progress.

4. Expected Results

The IPRO will be considered successful if a working prototype of a murine-scale shaker bed with precise, real-time control of the oscillation is built. In addition, the research should generate a comprehensive reference source for information regarding the

legalities and procedures pertaining to creating new medical technology and testing human subjects.

For the Mouse Team, the following results should be generated: schematics of the final design, a program to calculate necessary motor torque based on size of the desired subject, and a working prototype.

For the Human Team, the following results should be generated: a comprehensive reference source for information regarding the legalities and procedures pertaining to creating new medical technology and testing human subjects, and schematics of a human shaker bed.

5. Project Results

Since the design has not been finalized an accurate, detailed budget cannot be submitted at this time. Estimates and a general survey of available products yields the following estimated budget.

Item	Estimated Cost
Rotary Electric Motor: motor and attendant equipment	$2500
Electronic Components: resistors, op amps, wires, etc.	$1500
Soldering Equipment	$250
Aluminum Beams	$250
Color Posters: printing and posterboard	$200
Electronic Sensors	$75
Aluminum Sheet	$50
Bearings and Fasteners	$25
Total:	**$4850**

6. Schedule of Tasks and Milestone Events

The major tasks and milestones of the project, what they entail, and their expected due dates are listed in the following chart.

Mouse Team				
Task	**Entails**	**Expected Hours**	**People Required**	**Due Date**
Get specifications	Speaking with Harshbir Sidhu, getting his papers and calculations	5	1	September 18
Preliminary Design	Performing engineering calculations, generating simple schematics of the device, estimating the budget	15	4	September 27

Finalize Design	Verifying calculations, generating schematic drawings, getting design approved by advisor and researchers, submitting parts and purchase orders	10	All	October 4
Construction	Building a prototype of the device	25	4	October 27
Troubleshooting	Testing and modifying the prototype as necessary	35	4	November 22
Human Team				
Calculations and Scaling	Speaking with Harshbir Sidhu, getting his papers and calculations, using them to calculate the proper scaling of a device for human use	10	1	September 25
Researching Legal Issues and Procedures	Searching online and in libraries for resources on building, patenting, and testing new medical technology	30	2	October 16
Structure Design	Design a device based on the mouse shaker bed model that will work on human-sized subjects	15	2	October 30
Research Market	Speak to paramedics and other personnel to ascertain the approximate level of interest in a device such as this for practical use	10	All	November 22
Locate Sponsors	Investigate potential sponsors	TBD	All	As Time Permits
IPRO Deliverables				**Responsible Party**
Project Plan	Create a project plan in accordance with	15	September 22	Team Secretary,

	IPRO guidelines			Subteams
Midterm Report	Create a midterm report in accordance with IPRO guidelines	15	October 20	Team Secretary, Subteams
Exhibit/Poster	Create the booth display for IPRO Day	5	November 22	All
Project Abstract	Create an abstract of the project for IPRO Day	5	November 22	Team Secretary, Subteams
Website	Create the website, update it as progress is made and milestones are reached, submit it for IPRO review	TBD	November 27	Web Designer
Final Presentation	Create a Powerpoint Show and script for the IPRO Day presentation	10	November 29	All
Final Report	Collect summaries from each team member and combine into the final report of the semester	20	November 30	Team Secretary, Subteams
Team Information	Submit information about the IPRO team members	2	November 30	Team Secretary
Comprehensive CD	Collect all relevant documents and compile them on the CD to be distributed at IPRO Day	1	December 1	Team Secretary

7. Individual Team Member Assignments

IPRO 332 consists of the following personnel:

Prof. Francisco Ruiz – MMAE Department – Advisor, Team Leader
Harshbir Sidhu – Mechanical Engineering Graduate Student – Researcher/Aide

Mouse Team:
John Burica – Electrical Engineering
Patrick Folz – Aerospace Engineering – Subteam Leader, Team Secretary
Grant Justice – Mechanical Engineering
Maribel Valdez – Aerospace Engineering

*The Mouse Team will construct and test the mouse shaker bed. Subteam roles are fluid, though John will focus primarily on the design and construction of the power supply for the motor. The other three will focus on the mechanical design and construction, with Patrick and Maribel performing the calculations and Grant researching available products and creating the schematics. All three will collaborate on the construction of the shaking mechanism.

Human Team:
Jakub Krynski – Electrical Engineering
Alok Patel – Biomedical Engineering – Subteam Leader
Hazel Ramirez – Biomedical Engineering
Yun Wei – Electrical Engineering – Web Master
*The Human Team will research and design the human shaker bed. Alok will work with Harshbir on the calculations. Hazel and Jakub will perform the necessary research. Yun will create and maintain the website. All will collaborate on the design of the human bed.

8. Designation of Roles
During meetings the specified roles will be filled by the following people:
Minute Taker – Patrick Folz

Agenda Maker – Prof. Ruiz

Time Keeper – Patrick Folz

The status roles have been assigned to the following people:
Weekly Timesheet Collector/Summarizer – Grant Justice

Master Schedule Maker – Patrick Folz