Suggested Projects Book

EBME370 / 380

Fall 2008

Case Western Reserve University

Department of Biomedical Engineering

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Project ID and Title *Description* Company sponsored projects formated like this.

Great Lakes Science Center - Interactive Exhibit Design Project

Project ID: **69**

Engage visitors at the Great Lakes Science Center in an interactive exhibit to compliment the Functional Electrical Stimulation (FES) station in the BioMedical Technology Gallery . The current FES station in the gallery presents video, photos and text to portray the benefit of FES to those individuals who use this technology. An new interactive exhibit should appeal to the varied age range of the GLSC visitor to help them to understand the concept of FES.

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Better patient alert system for Medtronic defibrillators

Project ID: **60**

Medtronic defibrillators currently have audible patient alerts to notify both the patients and doctors of clinically relevant scenarios with the device, leads, and system as a whole. Oftentimes, these audible alerts are not heard by the elderly patients causing them anxiety and uneasiness. This project will design an external device for patients to use the current functionality of the defibrillator to better translate the sound of patient alert to a means that all patients can identify easily.

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Interactive Video Games for Research

Project ID: **70**

Design a suite of 'video games' that will enable paralyzed individuals to practice controlly different types of translational and rotational movement using various input devices.
Games must meet specific design specifications as well as be interesting and fun to keep the players engaged

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Motorized tracking system to follow patients

Project ID: **65**

A motorized system for tracking subjects walking in a gait lab. Currently experimenters pull cables beside walking subjects. This obscures motion capture markers from wall mounted cameras resulting in lost data. Cables drag along the ground or are suspended from a trolley on the ceiling. The goal is to motorize the trolley system so that either a) an operator could control its speed with a switch or joystick so that it's always next to the subject, or b) the system automatically matches the position of the trolley to a marker placed on the bod, tracking the subject in real time (how cool would that be?)

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Reliable, implantable hybrid high-density neurostimulation connector

Project ID: **62**

Recently, great advances have been made in the processing of high-contact density neural interfaces using liquid crystal polymer and polynorbornene hybrid MEMS processing techniques. These new devices offer the promise of the next generation, highly advanced neural interfaces. One of the gaps remaining to implementation of these devices is connecting between the MEMS system and external stimulation and recording hardware. This project seeks to fill this need and enable the implementaiton of these highly advanced electrodes.

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Acetone Sensor Assessment

Project ID: **56**

Fitness-centered individuals and dieters seek to monitor and control body fat. Properly done, one must monitor their diet for a precise balance of fats, protein and carbohydrates that disrupt the creation of glucose from carbohydrates and force ketone body production from fat --monitoring ketosis is an important part of ensuring the proper diet exists. Most ketone bodes are readily used for energy (heart muscle, kidneys, brain cells) but acetone cannot be used and is excreted (normally at very low levels) as waste in the urine and breath. A sensor has been developed for measuring acetone levels in the breath and this project with a start-up company in Cleveland involves the development, calibration, and validation of system for calibrating these sensors.

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DME Diffusion Model

Project ID: **58**

Rebreathing techniques for pulmonary capillary blood flow (Qc) are being used to answer questions about asthma and other clinical states. While rebreathing techniques are simple to conduct and are noninvasive, broader acceptance of such methods relates to the sensitivity of the methods to inaccuracies not readily explainable about the technique, namely, inspired volume, frequency, breathhold sequence, and (inert) tracer gas. Recently a technique for mucosal blood flow rebreathing with the use of dimethyl ether (DME) has shown promise at the MetroHealth pulmonary lab, but improvements are believed to exist in the modeling of DME diffusion. This project would focus on the development of a simple shell and tube system to simulate the diffusion of DME in a bronchial airway to potentially improve the rebreathing calculation sequence.

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Light-weight grasper for wheelchair-bound individuals

Project ID: **61**

There are two variations to this project:

1.
The project involves building a lightweight grasper for an 11 year old kid with a rare type VI collagen mutation (Ulrich's myopathy). Patients with this disability are wheelchair-bound by the time they are ten and with their weakness, they develop contractures. A grasper designed for the elderly is not suitable for our patient, as he does not have enough distal strength to even lift it. He has just enough strength to use the wheelchair joystick and play a gameboy. There are two goals here: One is to design a grasper that would meet the patient's needs, the other is to simply introduce him to engineering as a discipline and excite him about science. This would be a great project for a student in the biomechanics concentration.

2.
Spinal cord injured patients, especially quadraplegic patients, and other individuals confined to a wheelchair cannot easily reach to the floor to pick up objects. Available tools or assist devices do not typically have enough gripping power or adequate prehension to pick up a wide range of objects. The objective of this project is to develop and implement a non-obtrusive device that allows a patient confined to a wheelchair to pick up wide variety of objects from the "workspace" floor around the wheelchair.

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Automated analysis of sounds arising from the heart and lungs

Project ID: **54**

We often detect the first signs of serious trouble by auscultating the chest for heart and breath (lung) sounds during anesthesia and surgery. One cannot always decide if a sound is truly abnormal, especially when one is not trained over many years. The basic concept is :

a.
To use a humanoid simulator (SimMan) that emits 8-12 heart sounds and 12 breath sounds that can be changed by a program that controls the entire mannequin

b.
To create a small system of microphones (or equivalent) that would transmit the audible signals to a DSP

c.
To store and analyze the signals in an attempt to quantify “normal”, "abnormal type 1”, etc where abnormal would be rales, ronchii , wheezes, stridor etc and mitral regurgitation, or stenosis etc., each having (I would guess) a different Fourier Descriptor.

d.
To sound an alarm or alert when an abnormal is detected
This system has an advantage that one microphone might be sufficient to transduce breath and heart sounds, could be developed on the mannequin and then applied to a human volunteer who could at least imitate a wheeze and stridor. If the system works well it could then be taken into the OR for human trials.

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IV Placement Simulator

Project ID: **51**

Physical arterio-venous vascular system to permit realistic hands-on training for intravascular placement of pressure and flow measuring catheters in the operating room or emergency suite. The project probably comprises MANY smaller projects. The finished project could be used extensively in training MD's and other anesthesia and emergency medicine staff in proper insertion and wave interpretation. Even if there is no "final product" the experience of DOING the project would create a better Biomedical Engineer!

A. Components

i.

Vessels with realistic elasticity, needle penetrance characteristics, and re-seal capacity against high pressure (140 mmHg) or low pressure (10 mmHg)

ii.

Pressure and fluid flow sources to re-create the time modulated aortic pressure and flow characteristics.

iii.

Pressure and flow measuring devices (supplied by Cechner from current technology stock in anesthesiology)

b.

Special pressure modulation requirements

i.

If in an artery – aortic root profile and the ability to simulate aortic stenosis and regurgitation (well known profiles). To produce down-stream pressure profiles (radial/femoral – well known profiles)

ii.

If in a central vein – CVP pressure waveforms – normal and with TCV stenosis and regurgitation (well known profiles)

iii.

When a PA catheter is inserted to different depths the ability to transition from CVP (ii above) to right ventricular pressure profile then to pulmonary artery pressure profile and then to the wedged pressure (all well known profiles).

c.

Special flow modulation requirements

i.

If in an artery the ability to increase or decrease flow in order to measure the flow with a standard or advanced PA catheter using thermal dilution. (device supplied by Cechner)

d.

Special anatomical requirements

i.

The major simulation to be the neck with subclavian vein

ii.

Skin should be "realistic" with "realistic" subcutaneous tissue (materials science)

e.

Control

i.

The ability to control all functions from a "control box" or – better - a computer program written in a common language (VB.net, C##) when the device/system is 20-30 feet away from the controller.

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System for Automated Anesthesia

Project ID: **47**

This project would involve creation of the sensors, feedback system and controller that would permit AUTOMATED IV or volatile (inhaled) anesthesia. A few attempts have been made that would serve as a nidus for the student work. It is a very rich, multi-faceted project that could be broken into small parts for a team effort.

Automation of anesthesia/analgesia/amnesia protocols using computers, gas and fluid flow controllers with physiological parameter sensors for feedback to the controller. This has been done at very primitive levels and while it might seem complicated it can be broken into many small projects – each manageable. Realize that anesthesia providers do this kind of control hundreds of times each day – THEY are the controllers – and sometimes make mistakes or give less than theoretically optimal care that can lead to problems such as "post operative cognitive dysfunction –POCD) – they are human. Even if there is no "final product" the experience of DOING the project would create a better Biomedical Engineer!

A.
Components

i.
Methods for measuring impacted physiological parameters such as heart rate, breathing rate and depth, muscle contractility, urine flow (mL/min), core and peripheral temperature and level of "consciousness" . All of these are currently implemented in the operating room by the anesthesia care team. Some devices are available, others might have to be developed or emulated.

B.
Basic requirements

i.
Knowledge of volatile and non-volatile anesthetic agent pharmacokinetics and dynamics (well known for most agents)

ii.
Knowledge of the effect of the agents on the heart, vascular tone, brain function, renal, hepatic and uterine function, adrenal and thyroid function (most well known).

iii.
Using a basic anesthetic plan and allowing the controller to create and optimal physiological state for the patient.

C.
Structures

i.
The patient can be a computer "simulation" that responds to the agents in a predictable fashion as predicted by well known physiology of anesthetic effects

ii.
As agents are delivered with feedback the controller should adjust agent delivery to approach the target states defined earlier.

D.
Implementation:

i.
It is unlikely that the system would reach implementation in the real world until developed and proven under strict scrutiny in a simulated environment. However working with a computer simulated patient and accurately simulated physiological parameters the controller could be tested under many different circumstances. Even if there is no "final product" the experience of DOING the project would create a better Biomedical Engineer!

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The Effect of a Liner on the Dispersion of Backboard Interface Sacral Skin Pressure

Project ID: **46**

The early management of the trauma victim with a potential spinal cord injury begins at the scene of the accident. The recommendations of the American College of Surgeons consist of a hard backboard, a rigid cervical collar, lateral support devices, and tape to secure the patient to the backboard. The most important concern during the initial management of trauma victims is that neurologic function may be impaired due to movement of the unstable or injured vertebrae. While spinal immobilization is typically effective in limiting motion, it has been associated with skin breakdown.

We studied 40 volunteers between 18 and 60 who had no acute pain or illness, were not pregnant, and had no history of back problems. An FSA pressure mapping system (Vista Medical, Canada) was used to monitor sacral interface pressures in volunteers lying on a standard backboard and on a pressure dispersion liner placed over the backboard. Pressures were recorded every minute over a 40 minutes period. The highest pressure generation was found at the sacral prominence of each subject with little variation over the assessment period. Peak interface pressures were higher on the backboard alone than with the pressure dispersion liner (mean 260mmHg vs. 188mmHg). Paired Student T-test showed this difference was highly significant ($p<0.01$). Generation of early post-acute sacral decubiti may be related to the initial interface pressures generated while the patient is strapped to the backboard and may necessitate a change in backboard design. Adding a pressure dispersion liner on the backboard decreased overall mean sacral pressures by 28% over a 40 minute period.

The significance of the findings of the initial study warrant further investigation into the redesign of the backboard to prevent the formation of decubitus ulcers.

The objective of the second step of this project will be to redesign the backboard to determine the effects of spinal immobilization on healthy volunteers with respect to sacral interface pressures and pain scores.

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Multi-lead in-line connector for implanted systems

Project ID: **39**

As we improve electrode design and interface with the nervous system, the number of stimulation and control channels that can be implant is increasing exponentially. Our current systems of connectors are designed for only single channels or, at most, four. This project is to design an multi-channel connector for neuroprosthetic systems.

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Development of an instrument that facilitates placement of a lag screw for reduction and compression of mandibular symphyseal fractures

Project ID: 2

Symphyseal fractures of the mandible are those which involve the symphyis or parasymphyseal region. The treatment of these fractures is often reduction followed by internal rigid fixation using hardware. Access to these fractures tends not to be very difficult to obtain. The potential difficulty lies in the curvature of the mandible at this location. If plates are used and are not perfectly bent to the curvature of the mandible the mandibular curve can be altered significantly resulting in an altered dental occlusion and temporal-mandibular joint disruption on one or both sides. A well suited solution to this problem would be the placement of a lag screw—a screw that traverses both segments of the fractured mandible. This screw, when appropriately tightened not only realigns the two mandibular segements but also applies compressive forces that are thought to result in better primary bone healing. Two lag screws are needed at this location for adequate mandibular fixation.

The challenge is getting the lag screw perfectly placed. This means drilling a 3-5cm hole through solid bone (the 2 segments are aligned and stabilized in their anatomic position during the drilling) using only hand-eye coordination to guide the drill bit. This is often not good enough. Not only must the surgeon drill through sufficient bone (in both segments) for good purchase, he/she must avoid injuring tooth roots and the mental nerves which exit the mandible in close proximity to the fracture on each side.

This project entails designing a device that would facilitate placement of such a screw in the mandible. It must allow for precise measurement so screw length can be determined and it must reliably guide the drill to the intended target. In addition it has to be comfortable to use and non-bulky as the operative field is small.

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Vehicle Transfer Assist

Project ID: 31

As people age or have disabilities, they have increasing difficulty getting into vehicles, especially SUVs and larger vehicles. The purpose of the project is to develop a personal vehicle transfer device to assist entry into a vehicle.

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Continuous Passive Motion

Project ID: **37**

There are two variants on this project:

1.
Following limb injury, central nervous system injury, joint reconstruction and many others, continuous passive motion (CPM) is a prescribed rehabilitation treatment. CPM consists of a machine or device that continuously moves a joint through a prescribed range of motion at a prescribed rate. There are two possible projects in this area. First, design a new CPM machine for a joint, such as the knee. Second, present CPM machines are heavy and difficult to use. More problematic, however, is that they tend to move during use. This requires constant attention, monitoring, and "MacGyver" solutions by the therapist to stabilize the device. The project would be to modify or improve the design to eliminate these problems.

2.
A continuous passive motion wheelchair leg rest for total knee replacement patients. Adding a CPM type device to a wheelchair so early total knee patients could be passively exercising the new joint and working on mobility while seated in a wheelchair between therapy sessions, or between walks during a therapy session.

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A novel substrate for testing the ISSD (integrated surface electrical stimulation device)

Project ID: **67**

Multiple therapeutic applications in acute clinical care and rehabilitation could also be positively affected by utilization of electrical stimulation (ES) as a platform modality. We are currently developing an integrated surface stimulation device (ISSD) that will provide a novel surface stimulation platform technology with the potential for widespread clinical utility. The ISSD uses advanced materials, fabrication techniques and design together with a simple, user-friendly communication interface in a novel medical device costing less than $100. The ISSD is a portable, flexible, disposable single channel stimulation system which will be initially developed for the treatment for chronic wounds. Prior to application of the ISSD in a clinical trial it is important to determine the effects of the prototype device on the underlying soft tissues. This cannot be achieved using human subjects.

The goal of this design project is to develop a composite biomaterial that can mimic the anisotropic electrical properties of the soft tissue layers (skin, fat and muscle) and be used in experiments to determine the electrical fields produced by application of the ISSD stimulation to the surface of the material.

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Three-dimensional wound model

Project ID: **68**

Chronic non-healing wounds are a major clinical challenge in the long-term care of many patients with physical impairment. The investigation of novel wound therapies requires reliable outcomes measures of healing. In order to monitor wound healing over time, repeated assessments incorporating reliable objective measurements of wound dimensions are essential. New techniques for wound measurement are being developed and a wound model to test reliability is needed.

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Modification to walker

Project ID: **64**

A walker with forearm supports that are spring-loaded or hydraulic/pneumatic to rise with the patient during the sit-to-stand transition. For pts. with weak quads and triceps who can't power themselves up with their upper body strength. Platform walkers have arm trays so that users can put weight on their arms with the elbows bent. The problem is that they're always tall, so getting up from the wc is a problem. Telescoping uprights might work. Would have to be reversible, light, easy to operate, inexpensive, etc.

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Pulmonary Stent Failure Analysis

Project ID: **57**

Myocardial and cerebral stents (both bare metal and drug-eluting varieties) are widely utilized and design practice is fairly mature -- much design practice has been repurposed for pulmonary stents (bronchial and tracheal) primarily used for palliative care. Despite the fact that almost immediate palliation is achieved in 9 out of 10 cases, 3 out of 4 cases have severe complications, with stent migration and material failure the most common consequence. Cases have been reported in which stents are expectorated within less than 24 h. A critical issue appears to be underlying stent design issues, e.g, esophageal point loadings, (versus symmetric myocardial loading). Surgeons at the Cleveland Clinic have gathered a variety of stent data over time and this project has two potential directions:
1. Development of a "cough index" and characterization of physiological forces on pulmonary stents that can influence proper design.
2. Stent database analysis for historical failure attributes.

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UVB Wave Light Box

Project ID: **55**

Various skin conditions can be treated with phototherapy, in which the patient's skin is exposed to ultraviolet waves with the use of a "light-box." Treatment (or remission period) is often – but not always – effective or long-term and thus phototherapy remains a research topic. The School of Dermatology is interested in conducting research in this area, so this project is to design a narrow-band ultraviolet B (UVB) wave light-box.

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Automated interpretation of abnormal ECG morphology

Project ID: **53**

Current ECG monitors can be set to alert on tachy and bradycardias as well as ST segment deviation. However there are other easy to describe abnormal morphologies such as 1st , 2nd , and 3rd degree heart blocks or, importantly hyperkalemic T wave abnormality that are not detected by the routine monitors. The project would

a.
Use a humanoid mannequin that would emit normal and abnormal ECG (or a standalone heart phantom)

b.
Signals would be extracted and analyzed by Fourier Descriptors or equivalent to quantify the abnormalities.

c.
To signal the user which abnormality is detected.

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Drug delivery device fabrication

Project ID: **49**

I am currently compression molding drug delivery tablets made of polymer and drug, and would like to compression mold a ring (with known design parameters) instead.

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Circuitry for harsh environment

Project ID: **50**

We have a stirplate mechanism that needs to exist in our cell culture incubators. Due to humidity and temperature concerns the electronics part of the stirrer tends to get fried pretty easily while the stirrer part (purely mechanical) is OK. I'd like to separate the two mechanisms so that the electronics can exist outside and the stirrer inside.

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Tool for installing nerve electrodes

Project ID: **38**

Various peripheral nerve electrode designs have been developed and tested in animal models. They are now ready to move forward to clinical implementation. One critical element to successful clinical implementation is simple and minimally-invasive installation. The purpose of this project is to develop an installation tool for a specific electrode design developed in the labs at Case.

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Wheelchair transfer faciliation

Project ID: 17

Motorized arm rest/ entire side panel of wheelchair to facilitate easier transfers, without chair user having to squeeze a release and lift the side panel out of the way. I saw something similar for a trough arm rest for a stroke patient, but I missed the presentation so I do not know if it is the same as what I am thinking.

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"Smart" pill and medicine dispenser

Project ID: 36

As we age and the number of medication we need to take increases, it becomes difficult to keep track of all the medicines and the dosing schedules. This project is to develop a "smart" system and pill dispenser to help track and comply with medication usage.

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Goniometry

Project ID: 34

Goniometry refers to the measurement of joint angles. Available devices are either very expensive and hard to use or relatively inexpensive but unreliable. Most therapists use a modified protractor, set it against the joint, try to line everything up and take a measurement. This project is to design a simple to implement and inexpensive joint angle measurement system.

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Stair Assist

Project ID: 30

Elder people can often ambulate on level ground, but have difficulty with stairs. While there are elevator type lifts for stairs, they are expensive and are not portable. The purpose of this project is to develop a device that will help elderly or weaker patients to climb stairs.

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Assist device for bariatric patients

Project ID: **27**

Moving and assisting exceedingly obese patients is a difficult and dangerous task for physical therapists. The therapist may need to transfer a patient from a wheelchair to a table, assist will standing from a chair, or assist standing from a table. Typically this requires several therapist and involves risk of injury to either or both the therapist(s) and patient. The purpose of this project is to develop a easily transported and easily used patient transfer assist device. A similar project is for any transfer assist device. The target population could include SCI, stroke, obesity, etc. and the environment can be choosen, such as car, bed, chair, etc.

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Low-cost dynamic materials for pressure relief cushions

Project ID: **66**

Cushions play a major role in preventing pressure ulcers for many people with restricted mobility, in particular wheelchair users. These cushions have provided effective pressure relief for many users however the high cost limits their universal provision for all wheelchair users. There is a need to investigate the concept that dynamically responsive low-cost materials can be incorporated into a modular design cushion design to provide both pressure relief and postural stability.

A prototype cushion has been designed that uses “stress balls” to provide a pressure relieving interface. However, these balls tend to degrade and split after a short time. The goal of this design project is to identify and test dynamic materials that can be used to create a modular support device.

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Improved method of applying EEG electrodes

Project ID: **59**

It may be possible to improve upon the scalp abrasion/conductive gel method of preparing an EEG system by improving the syringe. For example, a syringe with several small tips might be more effective at getting through the hair and distributing the gel more evenly. The tips would also distribute the pressure applied to the scalp during abrasion, and hopefully make it more comfortable for the patient while at the same time abrading more effectively. It could reduce the possibility of twisting or pulling the hair as well as the risk of puncturing your poor test subject. There some hygiene issues that still need to be solved related to filling and refilling the syringe without contaminating the whole bottle of gel and thermodynamics issues about how to avoid air bubbles in the gel as the syringe is filled. Making the device more like a pipet that releases a predetermined amount of gel could avoid overfilling the electrode, which leads to gel leakage and electrode crosstalk. If it got really fancy, it could even measure scalp impedance as you prepared each electrode.

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Finding and quantifying neoplastic cells in thick sections of liver specimens (biopsies)

Project ID: **52**

This project was accomplished, with gaps, and can be done theoretically in order to show how to image thru a microscope, find cells by chromatin discovery and edge analysis, how to separate overlapping edges and how to determine if a cell is whole or cut in a thick section and then measure its volume and DNA content (ploidy).

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Weight bearing indicator

Project ID: **20**

Somehow modify the beeper boot we have that indicates if a patient is putting too much weight on a surgical limb. Current model requires setting the boot by stepping on a scale and adjusting the sensitivity so that the alarm works when too much pressure is applied. I'd love it if I could select one of five or six weights OR enter a weight digitally rather than messing around with the scale, trying! ! to get it right. Weight meaning number of pounds of pressure it will tolerate before making a sound.

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Pulse oximeter

Project ID: **19**

A pulse oximeter bracelet that could be worn on the wrist and strapped to the upper arm or worn like a small shoulder bag. The readout would need to be visible while in use/attached to the patient. My desired application would be to get a reading while walking a patient without having to have the patient walk with me holding the monitor on their index finger, waiting for a reading.

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