BME Design-Fall 2025 - KENNETH SUN
Complete Notebook

PDF Version generated by

Matthew Niemuth

on

Dec 10, 2025 @11:01 PM CST

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Team contact Information

KENNETH SUN - Oct 20, 2025, 1:31 PM CDT

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Project description

Course Number: BME 200/300

Project Name: Ski Jump Launch Trainer

Short Name: Ski Jump

Project description/problem statement:

This project aims to develop and prototype a comprehensive training system that enables youth amateur ski jumpers to compare their technique to that of expert jumpers and receive data-driven feedback. The system will integrate accelerometers, 2D motion analysis, and force plates to capture biomechanical data metrics, such as body joint angles, acceleration, and ground reaction forces, during the takeoff and initial flight phases. By analyzing relationships between these biomechanical variables and performance outcomes (distance and qualitative scores), the study seeks to identify which metrics are most highly associated with a more successful jump. The system will then provide coaches with targeted, evidence based feedback that can guide ski jumper training to optimize performance and bridge the gap between amateur and professional performance.

About the client: Dr. Ahmed is a UW Health Neurosurgeon and Associate Professor of Neurological Surgery and Radiology at the Wisconsin School of Medicine and Health. Dr. Ahmed treats patients with complex skull base tumors, brain tumors, and cerebral vascular disorders with non-invasive endoscopy, catheter-based, and stereotactic radio surgery techniques. Dr. Ahmeds daughter is an avid youth ski jumper and has been engaged in the sport for around five years and is the inspiration for this project.

9/16/25 - Preliminary Client Meeting (Questions)

KENNETH SUN - Sep 18, 2025, 7:03 PM CDT

Title: Preliminary Client Meeting

Date: 9/14/25

Content by: Team

Present: Team

Goals: Ask questions and get a gauge of project scope

Content:

Questions:

- What is your vision of the final trainer?
  - How it works, functionality, looks, etc
    - Image Capture (MoCap), Automated way to detect position of jumper, physics calculations. Segmenting jumper out of background.
    - In run, takeoff, flight, landing
      - Transition from in run to air flight
        - right angle, jumping on time
        - Jump hard as you can but keep your body stable as possible (Focus specifically on torso and arm)
  - How would we implement the force and the motion capture in this project
    - Force plate - force your able to generate within the take off jump. How can we relate to jump
    - Force insoles - can use within
  - Who would we use for the reference data from a professional ski jumper
    - How are we going to compare the pro jumper to the child's/amateur
      - Takeoff speed - get the general flight path first/ red line.
      - Perfect in run position captured off of mocap then the correct transition.
    - What data points would best represent a good jump.
  - What is the setting of the trainer - do we need snow or mountain
  - What is our budget for this project
    - 5000$
  - What is the scope of the project
    - Do you want the trainer to just analyze the biomechanics data and then compare with the user
    - Or actually give suggestions on how to improve
  - Would there be any standards we would need to follow
  - How old is your daughter
  - How much experience does your daughter have with ski jumping
    - Was she ever injured doing the sport
  - Would you want this trainer to be specified for youth athletes in general all ages

○ Do you have any safety concerns or general concerns about the design and function of the trainer?

Consent forms - human subject testing (Minors) Dr.Ahmed will help

Practice jumps: Sitting and then getting into the angle

Anna hoffman, aestella - National Team members.

- team norway (olympic jump footage)

- Coaches post perfect side view youtube (Ailah)

More kids to try the system.

The takeoff angle is pretty flat which is very similar to the

Training Facility: Blackhawk Ski Area

Follow Up Questions:

What specific motion capture system should we use? Would it be easier to use open capture or would a full suit with markers be better?

Need to ask Dr.Ahmed about consent forms and the consent process for studying minors and adult human subjects

Conclusions/action items:

Preliminary meeting went well, Dr.Block and Matthew could not make it but Dr.Ahmed's daughter and her trainer (student from Edgewood) accompanied the doctor.

The main vision of this project is two-fold. First, we want to utilize forceplate analysis of the jump off through simulation of the movement via a fake bar and the mentioned chair practice position to then launch off with full extension of the legs on the force plates. Second we want to utilize the motion capture system at the actual training hill in Middleton and track various angles and the flight path. Both of these projects will start off with the amateur (Dr.Ahmed's daughter) and the professional (trainer) but there are plenty of younger athletes that could participate and even olympic level talent too.

The main metrics we might want to measure are

Vertical Ground Reaction Forces at the takeoff jump

Dorsiflexion range of motion angle

Hip flexion range of motion angle

COM COP - similar calculation but for the upper body because this needs to be super stable during flight.

10/06/2025 - Blackhawk Ski Club Visit

CALEB WHITE - Oct 08, 2025, 2:10 PM CDT

Title: Blackhawk Ski Club Visit

Date: 10/06/2025

Content by: Caleb White

Present: Everyone

Goals: Observe the actual environment that the system will be used in. See roadblocks and potentials of the environment and begin to visualize its application.

Content:

The Blackhawk ski club is in Middleton, Wi. There are two main ski jumps that we will be looking at. We will use two cameras, one orthogonal to the ski jump and the other from the judge's perch. Finn is going to provide a rubric for the scoring guidelines of the judges as for younger athletes there is more of an emphasis on form.

Conclusions/action items:

The idea that the group will have to find evidence for the statistical assurance of variable influence on outcome score can be reduced. The testing that will be required is much less and

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KENNETH SUN - Dec 09, 2025, 10:09 PM CST

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9/16/25 - Dr.P Preliminary Meeting

KENNETH SUN - Sep 16, 2025, 3:08 PM CDT

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items:

9/16/25 - Dr.Willie Biomechanics Preliminary Meeting

KENNETH SUN - Sep 16, 2025, 3:05 PM CDT

Title: Dr.Willie Biomechanics Preliminary Meeting

Date: 9/16/25

Content by: Kenneth Sun

Present: Kenneth Sun

Goals: Receive advice about motion capture and force plate application for the project.

Content:

OpenSim - Markerless Motion Capture (Lab 3) First trial test: open access

- go through lab manual 3 first!

- practice: observe and maybe capture video in person to test opensim and see how well it works

-Lab fake jump: opensim + force plates

Lab 4: IMU's - inertial monitor units

Acceleration can tell stuff about forces - takeoff velocity (Phyphox)

Two IMU in specific locations can help get the angles you want

Pro level - IMU comes with the software (Auto Calculate angles)

- Do some research on pro level IMU and find the pricing

Look at exactly upper metrics:
Deviation of the torso - Look into how we could measure it

Find this from existing research on ski jump (pole vault)

Conclusions/action items:

 Need to research IMU available and look into openSim - Specifically if opensim is capable enough for outside real world usage at the ski hill.

9/22/25 - Dr.Bartels Preliminary Advisor Meeting

KENNETH SUN - Sep 24, 2025, 12:23 PM CDT

Title: Preliminary Advisor Meeting with Dr.Bartels

Date: 9/22/25

Content by: Team

Present: Team

Goals: Meet Dr.Bartels and explain to him our goals and see what he can do to help us with the project.

Content:

Equipment is there, capture data look at differentials, look at. things to improve to create new protocol.

Very difficult to find parameters of design. What is good design, what is bad design, and what metrics would be best compared to others.

Want to apply measurements to then apply statistical analysis.

How important are the relative angles?

Performance metric: Score on a ski jump

PROBLEM: We need to define a more wide problem not just we need to help the surgeons daughter to get better.

1. What metrics can we really quantify with our budget and our tools.

2. What is our goal/performance metric? Improve ski jump score (needs to quantifiable), improve distance of the jump horizontal, injury prevention?

3. If we only have two people - Can we do multiple jumps so statistics is more impactful

Do these metrics correlate with what they think will happen.

What are our designs and our other designs: what are the tradeoffs and how can we make our choices.

What is design? what is the trade off of the data? how can we quantify them?

Complication - Figuring when we can get data- we need to get prototypes very early, this is because we need more data over time to do statistical analysis.

Ten papers - 3 papers have 1 model these 3 have another model - competing models and then we do real world measurement to see which model is better.

See if you can get coach to provides scores for each jump: physics model plus data.

Have a sled put instrumentation and see the ideal projectile motion path. What parameters can we vary to fit our goal (jump farther).

Conclusions/action items:

Meeting with Professor Bartels was extremely informative and helpful in dialing in our project. Since we are doing a biomechanics based research project, there needs to be a very direct performance metric that we are trying to strive for (identify the problem and our goal). We also need to decide on what metrics we can actually test for with our budget and these could be our competing designs. Once we have this dialed in we can begin to look for physics models of ski jumps and use that to help compare without data. Data is very important this means we need to have tons of data points/participants, or we need to have multiple jumps for each participant.

1. What is our Goal/Performance Metric? What do we want to improve in the daughters jump?

2. What metrics can we feasibly capture with our budget and skill constraints? Which metrics are the most important? Can each metric be a specific design (mocap = angles, force insoles = vertical ground reaction force, etc)

3. Existing physics models that we can use to guide our design choice? We e can compare our "pro" data and "youth" data with the physics model as another caveat of our project. Have coaches add a qualitative score to each jump we record to then have buckets of "good" jumps or "bad" jumps

4. Maybe even figure out a way to replicate the projectile motion of the jump if the client is not able to commit many hours for data capture. We need lots of data points from various participants or we need to many jumps from a single participant.

5. How do we then use all this to then look at the differentials of the youth athlete with the "pro" and the model and then give advice on what needs improvement.

Take a look into Veritasium Tom Brady video: https://www.youtube.com/watch?v=J3i3F2e4IYs

NIST technical bulletin and American Journal of Physics for research recommended by Dr.Bartels.

9/26/25 - Dr.Willie Second Meeting

KENNETH SUN - Sep 26, 2025, 12:37 PM CDT

Title: Dr.Willie Second Meeting

Date: 9/26/25

Content by: Team

Present: Team

Goals: Establish the research project and the independent variable and dependent variables etc

Content:

Measure different participants and compare metrics between those.

- Split the levels of amateur in quartiles - Look for biomechanics in each groups to see whats different

Power analysis to determine number of participants - Based off existing study (Hip flexion angle - or other things)

OpenSim - 2 Apple Devices for camera -

Force plate insoles - What are the outcome measurements we are going to pull from these insoles

(overall force, force divided into 20 sections, and more) Which ones do we want within our budget

Conclusions/action items:

Look into those variables for the force plate insoles to determine which ones to buy.
Begin to work with OpenSim and start playing around with it.

Design Matrix for outcome metrics.

https://www.kinovea.org/

https://www.dartfish.com/

10/1/25 - Dr. Bartels Second Meeting

KENNETH SUN - Oct 14, 2025, 12:23 PM CDT

Title: Second Meeting Bartels

Date: 10/1/2025

Content by: Kenneth

Present: Team

Goals: Continue discussion on study plan and design

Content:

We need to be able to justify why we chose each metric. Why did we choose beta angle and how does that logically help with the jump. Beta angle could be because of air resistance.

We need a model to relate the angle with whatever like drag or something.

precision of angle to score we get - to improve the score you want to

Find some sort of physics model that models drag for ski jumping and relate that to angles.

Velocity of launch and launch angle? could this be related to the simplest point kinetics model.

- Velocity and gyroptic rotation measurement could help get launch speed and rotation and position maybe - Velocity dependence drag coefficients.

University of Washington: Steve Brunton (CLT)

angle change with accelerometers so when your angle is this open you have this speed.

Conclusions/action items:

Look into models and equations that could help.
TWO ways to approach. - Use physics model or use Statistics model

Even if we don't have full physical model we can do error analysis.

10/9/25 - Dr. Bartels Third Meeting

KENNETH SUN - Oct 09, 2025, 1:14 PM CDT

Title: Bartels 3rd Meeting

Date: 10/9/25

Content by: Kenneth Sun

Present: Kenneth and Caleb

Goals: Figure out what to do about distance scoring vs style scoring since the kids don't score jumps based off distance

Content:

Make sure you get the coach to score the jump (preferably the jump).

One to two campaigns have data and have score than analyze it.

designing software analysis strategy that can produce these metrics and correlations with these scores.

Zero in on some specific question.

Client relationship must be a partnership - mutual respect (dealing with someone who doesn't know what they want)

IDEA: can't get scores

comparitive: consistency with form, estmimate relative velocity, pick a metric - infer distance based on kinetics model like velocity

Take video and overlay video with angles (good bad) so kid can see and change. (annotated videos)

Before and After (good/bad form) - Coach could watch each video and give a score or even the judges could watch and give assessment.

Think about the numbers we want in terms of data collection: Ask them to do 1 session or maybe 2 session

Resources for 2d videos of proffesional too.

Conclusions/action items:

Contact Finn - ask about judges watching videos after processing. Use scoring of judges and range of decrease and relate angle change

1. use professional ski jumping videos too

Asking Finn about weaknesses on each athlete and dial in on that metric

Try to get all in one or two days

Sophomores: Work on fabricating three force plates via instructables

Juniors: get accelerometers, timing gate and dart fish and get data asap

2025/10/14 - Dr.Willie Third Meeting

KENNETH SUN - Oct 14, 2025, 12:40 PM CDT

Title: Dr.Willie Third Meeting - Kinovea and Dartfish Video advice

Date: 10/14/25

Content by: Kenneth Sun

Present: Kenneth Sun

Goals: Learn more about Dartfish and Kinovea specifically how to get quality 2d video to input into the softwares.

Content:

Camera Setup Tips:

- Standardize
    - Perpendicular View to target path of motion
    - Tripod w/ Phone
    - Multiple video of same view (zoomed out, knee down, etc) Zoom in
    - 120 FPS at least - Frame rate
- Sagittal and Frontal View

Conclusions/action items:

Figure out camera settings that are best for video capture on kinovea, email Dr.Willie about old motion capture lab.

10//17/2025 - Dr. Bartels Fourth Meeting

Matthew Niemuth - Oct 17, 2025, 4:11 PM CDT

Title: Bartels Fourth Meeting

Date: 10/17/2025

Content by: Matthew Niemuth

Present: Matthew and Sarah

Goals: Get advice about wifi issue and be able to establish a method to give jumpers immediate feedback. Discuss current design plans.

Content:

Wi-fi issue: some type of Bluetooth connection to connect to iPad and display data from Arduino. Ask chatgpt for more solutions to this problem.

Once we have sensors, do another round of data collection and compare the data.

Went over current progress with Arduino and code and future steps.

Conclusions/action items:

Ask chatgpt for a way to use bluetooth to display our data to fix wifi issue, but it's unlikely it'll be fixed.

11/3/2025 - Dr. Bartels Fifth Meeting

PRESLEY STELLFLUE - Nov 19, 2025, 12:30 PM CST

Title: Bartels' Fourth Meeting

Date: 10/17/2025

Content by: Presley

Present: Matthew and Sarah, and Presley

Goals: Get advice about the ski hill closing issue.

Content:

Since the hill closing is out of our control, using videos as data is also okay.

Another option he suggested was to just use the force plates to measure our forces when using the plates, and then validating the weight with a scale or something.

Use the videos for primary collection, and then, in the final design, highlight the issues we faced.

Conclusions/action items:

Collect any more videos we would be able to and then go from there by using ourselves for testing the force plates.

11/19/2025 - Dr. Willie Fourth Meeting

CALEB WHITE - Dec 08, 2025, 1:56 PM CST

Title: Dr. Willie Fourth Meeting

Date: 11/19/2025

Content by: Caleb White

Present: Caleb White and Kenneth Sun

Goals: Meet with Dr. Willie and learn how to utilize the BME lab force plates.

Content:

Kenneth and I attended Dr. Willie's BME 315 office hours and received a demo on how to use the force plates in the ECB lab. The process if very straight forward and simply requires turning on the force plates themselves, opening the software, setting parameters and collecting data. The force plates are very high quality and extremely calibrated making them a great resource for calibrating our force insoles.

Conclusions/action items:

Now understanding the force plates in the BME lab, their application is necessary for the derivation of the calibration curve of our force insole readings.

11/21/2025 - Dr. Bartels sixth Meeting

PRESLEY STELLFLUE - Nov 21, 2025, 2:04 PM CST

Title: Bartels' Fourth Meeting

Date: 11/21/2025

Content by: Presley

Present: Matthew, Presley

Goals:

Content:

- Met briefly with Dr Bartels to give him an update on current workings.
- talked about fabricating the force insoles and replicating the results.
- Find metrics and a system to represent force distribution in the insoles accurately.

Conclusions/action items:

- Meet with Dr. willie to work on the force plates.
- Extract metrics from the videos/motion capture from previously.

9/26/2025 - Initial ME x BME team meeting

Matthew Niemuth - Sep 26, 2025, 2:20 PM CDT

Title: Initial ME x BME Team Meeting

Date: 9/26/2025

Content by: Matthew, Sarah, and Presley

Present: Matthew, Sarah, and Presley

Goals: Get on the same page with the ME team about what they are designing and coordinate future client meetings

Content:

What they're doing? What's the plan and what resources are they using?

AI tracking. They are looking to some kind of program or app that anyone can upload a side view video of the ski jumper and the program shows their jump metric data and compares it to an ideal.

Did Dr. Ahmed mention anything about splitting the budget? What do you plan to spend your money on?

The budget will be split 50/50 where both groups receive $1000. They found free body tracking software. They may buy some sensors for the ski jumpers to wear during their trials.

Would they be interested in coming to the Blackhawk ski training with us in a couple weeks?

Yes, travel plans still to be determined

Are they planning to talk to the client anytime soon?

Yes to figure out when to go to ski jump hill based on daughter's schedule.

Conclusions/action items:

Design Matrix

CALEB WHITE - Sep 26, 2025, 11:35 AM CDT

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BME_200_300_Ski_Jump__Design_Matrix.docx (748 kB)

9/26/25 - Research Study Main Design

CALEB WHITE - Dec 10, 2025, 9:26 PM CST

Title: Research Study Main Design

Date: 12/10/2025

Content by: Everyone

Present: Everyone

Goals: Designate the design of the research study

Content:
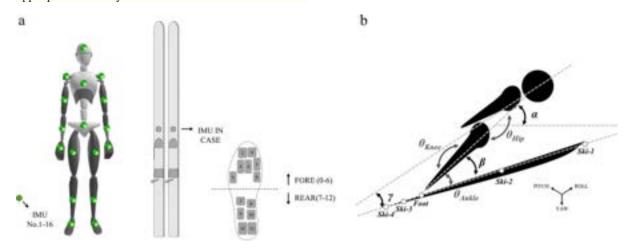
Metrics:

Body Angles:

alpha - angle of attack (angle of longitudinal axis of the body and the horizontal plane of the center of the gravity

beta -

Graph b presents the key angle parameters of an athlete's body posture during early flight. α, the angle of attack, is the angle between the longitudinal axis of the body and the horizontal plane of the centre of gravity. β is the angle between the longitudinal axis of the body and the ski. γ is the angle between the upper part of the body. Points ski-1–4 constitute the whole ski

Average force at takeoff:

Here are the results (average of 8 professional jumpers):

Table 1 – Body posture angles in early flight

Time point	α (°)	β (°)	γ (°)
T6 (takeoff/early flight start)	62.8 ± 1.9	75.3 ± 5.9	52.8 ± 5.0
T7 (start of stable flight)	56.8 ± 0.7	42.2 ± 1.6	29.6 ± 2.2
T7–0.30s (0.3 s into stable flight)	52.3 ± 6.7	28.0 ± 6.7	19.6 ± 6.0

Were there "best" angles?

The authors don't prescribe a single "best" value, but they do highlight trends:

- **α (angle of attack)**: decreases from ~63° to ~52°. A *smaller α* (leaning further forward) reduces drag and helps stability.

- **β (body–ski angle)**: drops sharply from ~75° to ~28°. Getting the torso closer to the ski is important for lift.

- **γ (upper body angle)**: falls from ~53° to ~20°. This reflects the jumper leaning forward aggressively.

They conclude that the most effective early-flight technique is to **quickly lean forward (reducing α, β, γ) and bring the body closer to the ski**. Aerodynamic studies cited in the paper confirm that:

- A **larger body lean** increases lift.

- A **smaller angle of attack** reduces inertial vibrations and improves stability.

So, the "best" isn't a fixed number but rather the **dynamic reduction of these angles as quickly and smoothly as possible after takeoff**.

Research Question: W Biomechanics Metrics will improve K-scores

Conclusions/action items:

With the designated tools and help of the coaches at Blackhawk Ski Club, use the above designated metric values as the standard for further evaluation in the research study.

10/31/2025 - Show and Tell Suggestions

Matthew Niemuth - Oct 31, 2025, 1:57 PM CDT

Title: Show and Tell Suggestions

Date: 10/31/2025

Content by: Matthew and Kenneth

Present: Everyone

Goals: Get suggestions for our project from other teams
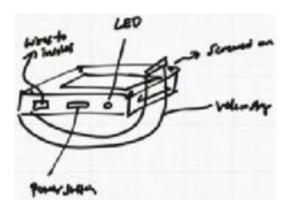
Content:

Suggestions:

- For testing, put one force plate in one shoe and put the other foot on a lab force plate and jump and test to see how similar the values are to see how close the force output values are.

- If data collection doesn't work out, do a simulated jump from the chair

- Create a hole to thread wires through to connect to the microcontroller on the outside closer at a more permanent spot so we don't have to worry about it getting messed up. Or we could do the hole on the back and put microcontroller storage on the back of the boot.

- Test if insole impacts force readings from force plate insoles

- Considering arrow dynamics, we should attach the microcontroller storage box on the back

- Make a latch for axis to accelerometer so that we could remove the accelerometer if necessary

- 50% infill carbon fiber PLA strap to keep box in place

- Velcro the microcontroller to the back of the boot

- Mini screw the box into the back of the boot

    - Research what screw is already on the boot to use to put the microcontroller onto the back.

Conclusions/action items: Implement suggestions that make the most sense for our design. More brainstorming required for this.

KENNETH SUN - Dec 09, 2025, 10:11 PM CST

Drawing.pdf (1.22 MB)

12/02/2025 - Force Insole Design Rework

CALEB WHITE - Dec 06, 2025, 9:48 PM CST

Title: Force Insole Design Rework

Date: 12/02/2025

Content by: Caleb White
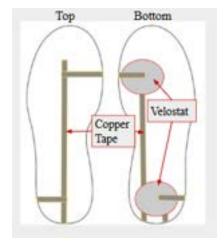
Present: Everyone

Goals: Redesign the force insoles

Content:

Following testing with the insoles it was deduced that the 4-location design is unnecessary and provides too large of a possibility of error. Having 4 locations of pressure would in theory give more indication of foot placement and weight distribution of the athlete but because of the nature of ski jumping and the system itself, it was decided to reduce the number of pressure locations to just 2, a forefoot and hindfoot location. Attempting to calibrate the 4-location insoles, it was first very difficult to get all 4 responsive and working correctly together at once. Second, it was understood that because of the linear trajectory of ski jumping, any form of pronation or supination is minimal and the need to identify this, which would be possible with the 4-location system, is not necessary. The two-location system allows for an easier calibration and more simple examination of weight distribution of front versus back weight.

Conclusions/action items:

The new 2 location design allows for easier identification of relevant problems with weight distribution and an easier calibration and fabrication process.

Current Expense Spreadsheet

KENNETH SUN - Dec 10, 2025, 12:41 PM CST

Title: Current Expense Spreadsheet

Date: Present

Content by: Sarah Kong

Present: Team

Goals: Display expense spreadsheet

Content:

Link to spreadsheet: https://docs.google.com/spreadsheets/d/1_kLPzdNUgeK5qO5MscxHWwflzIzkK6B-OuzJDpwLuqQ/edit?usp=sharing

Conclusions/action items:

Keep updating spreadsheet with 3D-printing and material expenses as the semester goes on.

KENNETH SUN - Dec 10, 2025, 12:41 PM CST

[Download]

Ski_Jump_Trainer_BPAG_Expense_Spreadsheet_-_Sheet1.pdf (77.6 kB)

10/29/2025 - Force Plate Insole Fabrication I

CALEB WHITE - Nov 03, 2025, 8:58 PM CST

Title: Force Plate Insole Fabrication I

Date: 10/29/2025

Content by: Caleb White

Present: Everyone

Goals: Construct the first rendition of the pressure insoles and begin to understand the ESP32 wiring and functionality

Content:

The team has been placed with a sudden constraint of available time to test and therefore needs to efficiently produce the force insoles in a number of days so that they can be used to collect data at the ski hill. Matthew, Sarah, and Presley worked together to fabricate the first two insoles (The full fabrication protocol of the insoles can be found under Fabrication -> Protocols). Kenneth and I worked on getting the ESP32 working, hooking it up to the accelerometer and gathering logical sensor values.

The sensor was quite difficult to work with because the pins being used in combination with the bread board did not create a stable and effective connection between the components, which prevented sufficient voltage from being supplied to the accelerometer. It is important to note that the sensor itself is fine and rather a bad connection was the culprit of the wiring issues. Because of this wiring issue, not much progress was able to be made in regard to the ESP circuit. 2 Force Insoles were fabricated, however, and can now be soldered and implemented into the larger circuit.

Conclusions/action items:

The ESP32 posed problems with voltage output that constrained the main electrical portion of the force insoles from making great progress, but the force insoles themselves were able to be fabricated and are ready for use once the circuit is made.

10/30/2025 - ESP32 Proto Board Fabrication

CALEB WHITE - Nov 03, 2025, 9:37 PM CST

Title: ESP32 Proto Board Fabrication

Date: 10/30/2025

Content by: Caleb White

Present: Kenneth and Caleb

Goals: Fabricate the proto board complex with the ESP32, the accelerometer IMU, and the associating wires and resistors for the circuitry of the system.

Content:

Seeing as the team is under an intense time constraint, fabrication of the completed circuit is necessary. All of the necessary materials to complete 1 of the boards have been acquired with further materials being ordered. The ESP32 Feather from Adafruit was soldered to a proto board along with the accelerometer. The connections between the SCL, SDA, 3.3V and GND pins on the ESP were made to the SCL, SDA, Vin and GND pins on the accelerometer respectively. The four 10K resistors that will apart of voltage dividers were also attached and collectively attached to the GND pin on the ESP32. The end of the resistors stick through the proto board and act as connection points for the alligator clips from the insoles to attach. The force insoles that were fabricated yesterday were also soldered with wires and all necessary resistance and voltage points were double checked with a digital multimeter.

Conclusions/action items:

The first ESP32 proto board was fabricated with the accelerometer. Once all insoles have been fabricated as well, the two can be soldered together to make one complete unit. The additional components for the other circuits are coming in the mail on Monday and will be used for further fabrication of these proto boards as four are needed for the two sets of boots being made.

📦 11/02/2025 - Force Plate Insole Fabrication II

CALEB WHITE - Nov 03, 2025, 9:42 PM CST

Title: Force Plate Insole Fabrication

Date: 11/2/2025

Content by: Sarah

Present: Everyone

Goals: Document fabrication steps for fabricating force plate insoles, write the WIFI code for the ESP32.

Content:

Two smaller force insoles, the size appropriate for the client's daughter were 3D printed and used to fabricate two more insoles (See Fabrication -> Force Plate Insole Fabrication). Further testing of the electronic circuit was done in conjunction with setting up the Wi-Fi code. There are slight concerns with the sensitivity of the system, as the pressure reaches a 'maximum' in the system too quickly. Other resistor options or complete other circuitry options such as filters of op-amps are being discussed.

The final Wi-Fi code achieved from this session:

```
#include <WiFi.h>

#include <Wire.h>

#include <Adafruit_Sensor.h>
```

```cpp
#include <Adafruit_ISM330DHCX.h>



// WiFi Access Point credentials


const char* ssid = "ESP32SkiJumping";


const char* password = "FadingFootball";



WiFiServer server(80);


Adafruit_ISM330DHCX ism;



// ADC pins for analog inputs


const int pinBack  = 32;


const int pinLeft  = 33;


const int pinRight = 34;


const int pinFront = 35;



void setup() {

  Serial.begin(115200);


  // Start WiFi AP

  WiFi.softAP(ssid, password);

  Serial.print("Access Point IP: ");

  Serial.println(WiFi.softAPIP());


  server.begin();
```

```cpp
  // Initialize accelerometer

  if (!ism.begin_I2C()) {

    Serial.println("Failed to find ISM330DHCX chip");

    while (1) { delay(10); }

  }

}


void loop() {

  WiFiClient client = server.available();

  if (!client) return;


  // Wait for request

  while (!client.available()) delay(1);

  String req = client.readStringUntil('\r');

  client.flush();


  // --- JSON data endpoint ---

  if (req.indexOf("GET /data") >= 0) {

    sensors_event_t accel, gyro, temp;

    ism.getEvent(&accel, &gyro, &temp);


    int rawBack  = analogRead(pinBack);

    int rawLeft  = analogRead(pinLeft);
```

```
int rawRight = analogRead(pinRight);

int rawFront = analogRead(pinFront);


float back  = rawBack  * (3.3 / 4095.0);

float left  = rawLeft  * (3.3 / 4095.0);

float right = rawRight * (3.3 / 4095.0);

float front = rawFront * (3.3 / 4095.0);


client.println("HTTP/1.1 200 OK");

client.println("Content-Type: application/json");

client.println("Connection: close");

client.println();

client.print("{");

client.print("\"AccelX\":"); client.print(accel.acceleration.x); client.print(",");

client.print("\"AccelY\":"); client.print(accel.acceleration.y); client.print(",");

client.print("\"AccelZ\":"); client.print(accel.acceleration.z); client.print(",");

client.print("\"Back\":"); client.print(back); client.print(",");

client.print("\"Left\":"); client.print(left); client.print(",");

client.print("\"Right\":"); client.print(right); client.print(",");

client.print("\"Front\":"); client.print(front);

client.println("}");
```

```
  }

  // --- HTML page ---

  else {

    client.println("HTTP/1.1 200 OK");

    client.println("Content-Type: text/html");

    client.println("Connection: close");

    client.println();

    client.println("<!DOCTYPE html><html><head><title>ESP32 Live Data</title></head><body>");

    client.println("<h1>ESP32 Accelerometer & Analog Inputs</h1>");

    client.println("<div id='log'></div>");

    client.println(R"(

<script>

let logDiv = document.getElementById('log');

function fetchData() {

  fetch('/data')

    .then(resp => resp.json())

    .then(d => {

      let now = new Date().toLocaleTimeString();

      logDiv.innerHTML += now +

        ': AccelX=' + d.AccelX.toFixed(2) +
```

```
                ', AccelY=' + d.AccelY.toFixed(2) +


                ', AccelZ=' + d.AccelZ.toFixed(2) +


                ', Back=' + d.Back.toFixed(2) +


                ', Left=' + d.Left.toFixed(2) +


                ', Right=' + d.Right.toFixed(2) +


                ', Front=' + d.Front.toFixed(2) + '<br>';


            logDiv.scrollTop = logDiv.scrollHeight;


        })


        .catch(err => console.log('Error fetching data:', err));


}


setInterval(fetchData, 2000); // update every 2 seconds


</script>


        )");


    client.println("</body></html>");


  }


  delay(1);


  client.stop();


}
```

Conclusions/action items:

The smaller pressure insoles needed for the client's daughter have been fabricated and can now be implemented with the ESP proto board circuitry. The above code is the WiFi code which outputs accelerometer and pressure data to an online interface.

11/03/2025 - Pressure Insole Circuit Fabrication and Gut Check

CALEB WHITE - Nov 03, 2025, 9:49 PM CST

Title: Pressure Insole Circuit Fabrication and Gut Check

Date: 11/03/2025
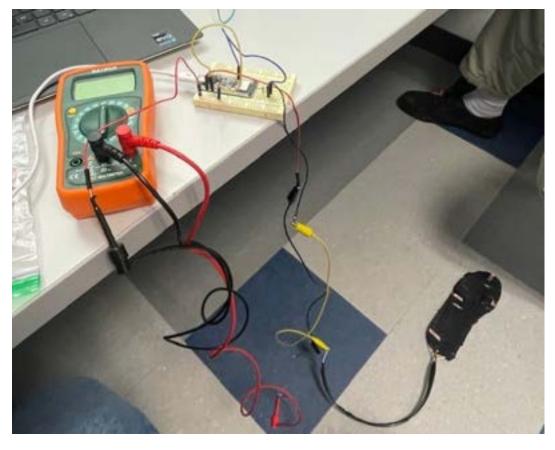
Content by: Caleb White

Present: Caleb and Kenneth

Goals: Figure the best way to make use of the pressure insoles by potentially decreasing sensitivity.

Content:

The pressure and circuit had been fabricated for at least 1 insole system and could be tested. As the system was being tested, we found that the Velostat resistive material was too sensitive to our touch and was reaching a max pressure value very easily. In order to fix this, the circuit was broken down into is bare components and was diligently checked with a digital multimeter. What was found was that there was nothing actually wrong with the circuit itself or necessarily the Velostat, rather just a characteristic of the Velostat. When a very concentrated pressure, such as a hard finger push, the Velostat is very reactive and almost immediately jumps to a minimum resistance value. However, when the entire foot it placed on the insole, because of the larger distribution of weight across the much bigger surface area, the velostat does not react as drastically and accordingly tracks pressure differences quite effectively.

Conclusions/action items:

The circuitry and setup of the force plates have no issues. The 10k resistor value was initially thought the reason for the issue but to no avail. The real issue was how the Velostat was being tested. A much more distributed force is much more advantageous for the material as it performs quite well, is quite responsive. A finer pressure point causes a very rapid decrease in resistance and therefore a very quick increase and voltage, reaching a max pressure value very quickly.

11/10/2025 - LIPO Battery Fabrication

CALEB WHITE - Dec 08, 2025, 1:34 PM CST

Title: LIPO Battery Fabrication

Date: 11/10/2025

Content by: Caleb White

Present: Caleb White

Goals: Fabricate the LIPO battery complex that will be attached to the microcontroller complex

Content:

In order to use the microcontroller, and therefore force insole and the accelerometer in the real world, some form of portable power is required. To do this, a 3.7V lithium-Ion battery was used. A switch was attached to the battery as well as an LED and resistor so the user can first turn the system on and off and so they are aware when the battery is actually on. The LIPO battery will be placed in the housing unit with the microcontroller complex, being the main influencer of the dimensions of the housing unit. The batteries gnd and voltage wires were cut and stripped, and the switch was then soldered to the voltage lead. From the switch was nothing on one end and the LED and then a pull-down resistor as well as voltage wire branched off. The pull-down resistor goes to gnd and the voltage branch attached to the microcontroller. The connection of the battery to the microcontroller used a JST plug so the LIPO complex can be taken off and replaced.

Conclusions/action items:

The LIPO battery complex was fabricated and checked to work on the microcontroller. Once the final code is uploaded to the microcontroller, the LIPO battery can used in full to simply control power output to the microcontroller.

11/18/2025 - Second Microcontroller Complex Fabrication

CALEB WHITE - Dec 08, 2025, 2:00 PM CST

Title: Second Microcontroller Complex Fabrication

Date: 11/18/2025

Content by: Caleb White

Present: Caleb White and Kenneth Sun

Goals: Fabricate the second microcontroller complex

Content:

Seeing as there will be copious testing done and there are two ski boots, a second microcontroller complex was fabricated. The group had ordered a couple of each component from Adafruit in case of breakage or to fabricate further multiples of the product. This process again involved the soldering of the ESP32 and IMU to a proto board, then connecting the two via SPI connection and further adding wires and resistors to incorporate the force insoles into the design.

Conclusions/action items:

With a second microcontroller fabricated, more testing can be done, and more risks can be made with testing as there is less of a worry of breaking the complex, seeing as we have a second working one. The group would also love to potentially provide multiple sets of the force insole product to the ski hill to aid in larger scale improvement of ski jumping.

11/20/2025 - Force Insole Testing First Steps

CALEB WHITE - Dec 08, 2025, 1:16 PM CST

Title: Force Insole Testing First Steps

Date: 11/20/2025

Content by: Caleb White

Present: Caleb White and Kenneth Sun

Goals: Finish the fabrication of the force plates and perform a gut check to see if the force plate testing calibration curve will work with the force plates.

Content:

Kenneth and I completed the fabrication of one of the force plates necessary for testing. We finished taping and wiring the insole and verified the insole worked by using alligator clips to ensure function. Knowing that the insole is functional, and general readings made sense, further assurance of insole function was done with the in-ground force plates found within the BME lab in ECB. The force insoles were placed on the force plates and several trials of placing body weight and jumping off were done. From this, the data recorded by the force insoles and the data recorded by the force plates were matched. This method showed the very early signs of a correlation which was a great sign as it ensured the use of the force plates for the calibration curve creation of the force insoles.

Conclusions/action items:

Knowing the force insoles are functional and there is a general relationship between the insoles and the force plates, a calibration curve can be constructed to quantitatively match force plate to force insole readings.

12/01/2025 - WiFi and Website code development

CALEB WHITE - Dec 08, 2025, 1:27 PM CST

Title: Wi-Fi and Website code development

Date: 12/1/2025

Content by: Caleb White
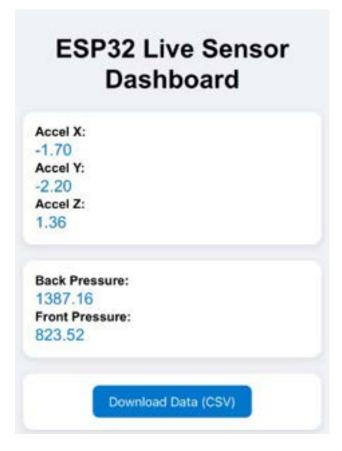
Present: Caleb White and Kenneth Sun

Goals: To finish the Wi-Fi interface, getting it to a point where it is easy to use and understand and consistently achieves and displays what we desire.

Content:

To finish coding the website, further HTML coding on the Arduino IDE software was necessary. The main addition of the code was the download CSV file button at the bottom of the webpage. It is important for the microcontroller to be reading the data, but the coach can't get anything out of it if he can't then use the data to actually analyze the athlete's performance. This button makes the downloading of data much more user friendly and will make the process much easier for the Coach Finn and Dr. Ahmed.

Conclusions/action items:

The webpage is now essentially fully functional and ready. There were always things being added in and out but the final design is as it looks above. The HTML addition of the Download CSV button will make the whole process much more user friendly.

12/03/2025 - Force Insole Soldering and Further Website Development

CALEB WHITE - Dec 06, 2025, 9:27 PM CST

Title: Force Insole Soldering and Further Website Development

Date: 12/03/2025

Content by: Caleb White

Present: Caleb White and Kenneth Sun

Goals:

Finish the fabrication of the insoles and test the website functionality with the fabricated insoles.

Content:

Kenneth and I worked together at the Makerspace to finish taping and wiring the new two-location insoles. The forefoot and hindfoot approach allow for an easier delineation of forward vs backward leaning and weight distribution. This process involved cutting out the Velostat to the appropriate size, placing the copper tape accordingly and taping the insole secure. Wires were then soldering to small pieces of copper tape at the end of the insoles and attached and secured with more copper and electrical tape. These insoles were then tested with the online interface to make sure all connections were still in good condition utilizing alligator clips.

Conclusions/action items:

As the symposium is on the horizon, continuous diligent work on the project is necessary. The completion of the insoles allows focus to be placed on the housing unit and the finishing of the poster itself.

12/04/2025 - Housing Unit Threads and Example Shell Model Fabrication

CALEB WHITE - Dec 06, 2025, 10:01 PM CST

Title: Housing Unit Threads and Example Shell Model Fabrication

Date: 12/4/2025

Content by: Caleb White

Present: Caleb White and Kenneth Sun

Goals: Thread the housing unit using a heat insert to allow for easy and long-lasting placement of the lid onto the housing unit using small screws.

Content:

In order to ensure longevity of the housing unit, placing threads in the unit to allow for continuous opening and sealing of the unit with the cap is necessary. The PLA material that was used to print the box is not effective for threading as the infill is not high enough and the material in general is too soft to last continuous strain from screws. Using a heat insert press, Kenneth and I were able to melt the heat inserts into the housing unit. There was a bit of a learning curve with the process and fixture but once Kenneth got a hang of the pressure required and the steady hand needed, the process was relatively smooth. We also worked on and finished the fabrication of the shell display of the boot. This meaning, the outside look of the entire force insole system placed inside of an actual boot. This will serve as a demo at the poster symposium. This involved finishing the insole, and soldering a few more things.

Conclusions/action items:

As the poster session is tomorrow and the semester coming to a close, it is important to get all things completed in time for their deadlines. With the work done today, all fabrication has been completed, and it is now presentation and deliverables that are left to show off and explain the work that has been done through the semester.

Force Plate Insole Fabrication Protocol

CALEB WHITE - Nov 03, 2025, 9:19 PM CST

Title: Force Plate Insole Fabrication Protocol

Fabricating the Force Insoles:

https://www.instructables.com/Wearable-Smart-Sensing-Insole/

1. 3D Print force insole template with 1 mm thickness in PLA

2. Use copper tape as traces to connect the sensing circuit. Traces must not touch each other and extra tape at the sensor locations to be folded back on itself. Measuring force/pressure.

3. Sensors are made using Velostat, an electrically conductive materials whose resistance changes as it is flexed or compressed. Cut into small squares or circles and secure each piece in place on the template using copper tape. Sensors must not touch one another or any neighboring traces.

4. Solder some thin gauge wire directly to the copper tape at the heel of the insole. These wires will carry data from each sensor to the micro-controller so they need to be long enough to reach to micro-controller attached to the outside of the boot. Secure the wire in place using hot glue and trim off any excess copper tape.

5. For a Velostat sensor to work, it must be insulated and sandwiched between two conductive layers (copper tape in this case) as it is a carbon-impregnated plastic so its electrical resistance changes predictably in response to physical pressure. The copper serves as the two contact points or electrode needed to complete the circuit and measure the material's variable resistance. Because of this, we must insulate everything but the Velostat on the first layer so put electrical tape all over but leaving the sensors mostly uncovered.

6. Then put copper wire over the top of the tape making sure copper tape makes contact with the sensor and it extends to the heel. Solder a single cable at the heel long enough to reach the micro-controller. Use hot glue gone over the soldered connection.

7. Connect the microcontroller, this part involved Arduino and connecting the individual wires to the micro-controller using a proof board.

Full Circuit Fabrication Protocol

KENNETH SUN - Dec 10, 2025, 8:09 PM CST

Title: Circuit Design Protocol

Date: 12/10/25

Content by: Caleb White

Present: Caleb White

Goals: Write protocol on how we assembled circuit system

Content:

Materials
• ESP32 Feather V2 microcontroller
• ISM330DHCX IMU (accelerometer and gyroscope)
• 3.7 V lithium-ion battery
• Slide switch
• LED indicator light
• JST connector (for modular battery/LED assembly)
• Proto board
• Soldering iron and solder
• Heat-shrink tubing or electrical tape
• Wires (thin-gauge)

Protocol

1. Component Preparation
   • Gather all circuitry components: ESP32, IMU, battery, slide switch, and LED.
   • Cut wire segments to appropriate lengths for connecting each component.
   • Prepare a proto board to serve as the mounting platform.

2. Microcontroller and IMU Connections
   • Solder the ISM330DHCX IMU to the ESP32 following correct pin alignment.
   • Route wires cleanly along the proto board to avoid short circuits.
   • Secure all soldered joints using heat shrink or electrical tape.

3. Power Sub-Complex Assembly
   • Connect the lithium-ion battery, slide switch, and LED together as a removable sub-complex.
   • Use a JST connector to link this power sub-complex to the ESP32 instead of directly soldering wires.
   • Verify that the slide switch interrupts the battery power line properly.
   • Ensure the LED lights when the system is powered.

4. Integration on Proto Board
   • Mount the ESP32 and IMU assembly onto the proto board.
   • Position the battery/switch/LED sub-complex so it can be easily removed for replacement.
   • Organize wire routing to minimize clutter and prevent strain on solder joints.

5. Final Inspection
   - Check all connections for secure solder joints and no exposed wires.
   - Confirm that the modular JST connection allows the power sub-complex to detach and reattach smoothly.
   - Power the system on briefly to confirm LED illumination and basic function.

Conclusions/action items:

This protocol outlines how the circuitry was assembled into a compact, modular system suitable for repeated outdoor use. The modular JST connection allows quick replacement of the battery or LED, while the proto board provides a stable foundation for the microcontroller and IMU during ski-jump data collection.

Microcontroller CAD Design Fabrication Protocol

Matthew Niemuth - Dec 03, 2025, 8:15 PM CST

Title: Microcontroller CAD Design Fabrication Protocol

Date: 12/3/2025

Content by: Matthew

Present: n/a

Goals: Document protocol needed to recreate our microcontroller box CAD design.

Content:

Microcontroller Storage Fabrication Steps:

1. Open Onshape and create a new document to make part

2. Create a new sketch on the Top plane and draw a 3.346 inches by 2.559 inches rectangle.

3. Extrude rectangle up 1.279 inches.

4. Create a new sketch on the top plane of the box and draw a center point rectangle 2.756 inches by 1.969 inches.

5. Extrude down into the box 1.1811 inches.

6. Create a new sketch on the right face of the box and draw a center point rectangle 1.969 inches by 0.394 inches.

7. Extrude rectangle from prior step 0.394 inches and duplicate it on the left side of the box.

8. Once both handles are extruded, create a new sketch and draw a rectangle from where the handle connects to the box to 0.275 inches across the handle. Set the length of this rectangle to 1.6 inches. Repeat on the other handle.

9. Extrude through the rectangles in the previous step to create the handles.

10. Create a new sketch on the front face of the box. Sketch a rectangle on the center of that face for the button 0.416 inches by 0.228 inches. Sketch another rectangle for the wire hole at the center of the right half of the front face 0.591 inches by 0.295 inches.

11. Extrude through the two rectangles in the previous step all the way through to create the button hole and the wire hole.

12. Filet all the edges of the box with a 0.079 inch radius.

13. Face blend the interior faces of the handles with a 0.2 inch radius.

14. Create a new sketch and draw circles for screw holes 3/32 in diameter and place them 0.204 inches away from the corner of the filet.

15. Extrude down into the hole sketches 1 inch deep.

16. Create a lid 0.098 inches thick with holes 0.204 inches away from the corners diagonally. The diameter of the holes should be 3/32 inches.

17. Save both files in stl. Format for 3D printing.

18. Print at Wendt and allow print to complete.

19. Remove the housing unit from the print bed carefully and clean up any support material using a small blade or file.

20. Make adjustments to the fit or openings if necessary.

Slow Motion Camera Protocol

KENNETH SUN - Dec 10, 2025, 7:39 PM CST

Title: Slow-Motion Video Recording Protocol (Sony RX100 VII)

Date: 12/10/25

Content by: Kenneth Sun

Present: Team

Goals: Record the procedure we used to record slo motion video on Sarah's camera

Content:

Materials and Equipment
• Sony RX100 VII camera
• NP-BX1 battery (charged)
• High-speed SD card (UHS-I U3)
• Tripod
• Lens cleaning cloth

Camera Settings Protocol

1. Power and Initial Setup
   • Turn the camera on
   • Insert SD card and check remaining recording time
   • Set Mode Dial to Movie (film icon)

2. Slow-Motion Frame Rate (HFR Mode)
   • Press MENU
   • Go to Camera 2 (Movie) tab
   • Select HFR Mode → On
   • Set HFR Frame Rate (recommended: 120 fps)
   • Optional: 240, 480, or 960 fps
   • Set Record Setting (recommended: 120p 100 Mbps)

3. Exposure and Focus
   • Focus Mode: AF-C
   • Focus Area: Center or Zone
   • Shutter speed: at least $1/(2 \times \text{frame rate})$

• Example: for 120 fps use 1/250 sec or faster
   • ISO: Auto or 100–800 for daylight
   • White balance: Daylight

4. Camera Positioning
   • Place tripod perpendicular to the ski jump ramp
   • Ensure entire in-run and takeoff region is in frame
   • Position camera 10–20 ft from the jumper path
   • Avoid backlighting and snow glare
   • Lock tripod head to prevent camera shake

5. Recording Procedure
   • Press the movie record button (red dot)
   • Record each jump ensuring the athlete remains centered
   • Stop recording after each jump
   • Review playback briefly for clarity
   • Adjust optical zoom if needed

6. File Transfer and Backup
   • Connect camera via USB or remove SD card
   • Copy MP4 files to project folder

- Label files by athlete ID, jump number, and date
- Back up files to cloud storage

Troubleshooting
- Footage too dark → increase ISO or open aperture
- Motion blur → increase shutter speed (1/500–1/1000)
- Autofocus drifting → use Center AF or pre-focus
- Stuttering footage → use U3 SD card; avoid digital zoom

Conclusions/action items:

This protocol standardizes the process of slow-motion video capture for biomechanical analysis, helping ensure that footage is consistent and usable for angle tracking in Kinovea.

- Label files by athlete ID, jump number, and date
- Back up files to cloud storage

Force Insole Calibration Curve Protocol

KENNETH SUN - Dec 10, 2025, 8:02 PM CST

Title: Force Calibration Curve Protocol and Steps

Date: 12/10/25

Content by: Kenneth Sun
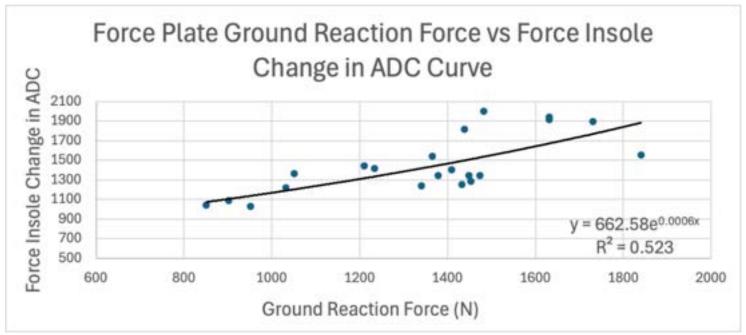
Present: Kenneth and Matthew

Goals: Record the procedure on how to develop a calibration curve for the force plate insoles with Bertec force plates

Content:

Force Plate Ground Reaction Force vs Force Insole Change in ADC Curve

$y = 662.58e^{0.0006x}$
$R^2 = 0.523$

Calibration Curve Procedure (Force Insoles vs. Bertec Force Plate)

• Place the custom force insoles directly on top of the Bertec Acquire Force Plate.
• Turn on the Bertec system and zero the force plate before testing.
• Isolate the Fz channel on the Bertec software, as Fz corresponds to vertical ground reaction force (vGRF).
• Position a chair at the edge of the force plate to simulate the ski-jump in-run posture (as recommended by the ski coach).
• Sit on the edge of the chair and lean forward at the hips to assume the pre-takeoff ski-jump position.
• Place one foot on the force insole (which is sitting on the force plate) so that the velostat sensors are directly under the contact point.
• Transition from the in-run position into a jump by pushing off the force insole and the Bertec plate.
• Record the vGRF curve for the entire jump using the Bertec software and export the data as a CSV file.
• After each jump trial, unplug the force insole wires to pause ADC data collection on the Arduino serial monitor.
• Open the ADC data and the force plate vGRF data and identify the force peak in each dataset.
• Correct the ADC values by determining the baseline "ADC zero" value before takeoff and subtracting this value from the recorded peak.
• Match each corrected ADC peak with its corresponding vGRF peak from the Bertec CSV file.
• Repeat this process for all jump trials, producing a total of 21 paired ADC–vGRF data points.
• Categorize the jump trials into low, medium, and high exertion groups to ensure coverage of different force magnitudes.
• Input all paired values into Excel and generate a scatter plot.
• Fit an exponential trendline to the data to create the final calibration curve relating ADC values to measured vGRF.

Conclusions/action items:

This calibration method allowed us to match ADC values from our force insoles with real force measurements from the Bertec force plate. By collecting 21 jump trials at different effort levels, we were able to create an exponential trendline that relates ADC output to vertical ground reaction force. Although the correlation was moderate, the curve is accurate enough to convert our insole data into usable force estimates for analyzing ski-jump takeoff performance.

KENNETH SUN - Dec 10, 2025, 7:43 PM CST

Dynamic Jump Table

Trial	Averaged ADC, From Insole	Force Fr. Force Plate
1 (light)	1300, 3291 ADC	1829.846 N
2 (light)	2098, 3499 ADC	1485.28 N
3 (light)	1300, 3312 ADC	1333.623 N
4 (light)	1390, 3350 ADC	1607.32 N

5 (light)	1400, 3251 ADC	1042.253 N
6 (light)	3000, 3453 ADC	1283.019 N
7 (light)	2000, 3340 ADC	1236.876 N
8 (medium)	1200, 3798 ADC	1345.387 N
9 (medium)	1700, 3919 ADC	1440.834 N
10 (medium)	1400, 3451 ADC	1362.360 N
11 (medium)	1200, 3914 ADC	1414.77 N
12 (medium)	3140, 3539 ADC	1342.504 N
13 (medium)	3196, 3503 ADC	1291.560 N
14 (medium)	1200, 3673 ADC	1347.243 N
15 (heavy)	1500, 3565 ADC	1542.276 N
16 (heavy)	1500, 3940 ADC	1555.909 N
17 (heavy)	1900, 3631 ADC	1897.91 N

[Download](#)

Sensor_Calibration_Curve_Testing_Protocol.pdf (260 kB)

Kinovea 2D Motion Analysis - Angles Protocol

Title: Kinovea Angles Protocol

Date: 12/10/25

Content by: Kenneth Sun

Present: Caleb White

Goals: Record the procedure of getting angle data using the automatic marker tracker tool on Kinovea

Content:

Materials
• Kinovea software
• Slow-motion video file (MP4 or MOV)

Protocol

1. Importing the Video into Kinovea
   • Open Kinovea and load the video file.
   • Confirm the frame rate shown in Kinovea matches the recording frame rate.
   • Trim the video to the section needed for analysis (in-run, takeoff, early flight).

2. Setting the Calibration
   • Select the calibration tool in Kinovea.
   • Draw a line over a known-length object visible in the scene.
   • Enter its real length in meters to set the scale for the video.
   • Optionally check accuracy by measuring another known object.

3. Creating Angles for Joint Tracking
   • Select the Angle Tool from the Kinovea toolbox.
   • Place three points to form the joint angle:
   – First point on the proximal limb landmark (e.g., hip for knee tracking)
   – Vertex point on the joint center (e.g., knee)
   – Third point on the distal limb landmark (e.g., ankle)
   • Repeat as needed to create separate overlays for knee angle and ankle angle.
   • Rename each angle overlay for clarity.

4. Using the Marker Tracking Tool
   • Right-click on a point of the angle and enable the tracking feature.
   • Choose the tracking mode (usually point tracking or color-based tracking).
   • Move through the video frame-by-frame.
   • Adjust each point manually whenever the tracking drifts or loses the joint.
   • Ensure consistent placement on the same anatomical landmarks every frame.

5. Tracking Angles Over Time
   • As each point moves, Kinovea automatically updates the angle value for that frame.
   • Continue tracking until the full motion phase of interest is complete.
   • Open the graphing panel to view the angle vs. time curve generated by Kinovea.

6. Exporting the Data
   • In the graph window, export the angle data as a CSV file.
   • Save files with clear names including athlete, angle type, and jump number.

Conclusions/action items:

This protocol provides a consistent method for capturing knee and ankle angle changes over time using Kinovea. By controlling camera setup, calibrating accurately, and tracking landmarks frame-by-frame, reliable sagittal-plane angle data can be extracted for ski-jump motion analysis.

9/29/2025 - OpenCap Testing

KENNETH SUN - Dec 10, 2025, 7:51 PM CST

Title: OpenCap Testing

Date: 10/01/2025

Content by: Caleb White

Present: Caleb White and Kenneth Sun

Goals: Get used to the OpenCap software and test the systems capabilities and attempt to make qualitative conclusions on application to project scope.

Content:

Materials
• Two iPhones with high-frame-rate recording
• Two tripods
• Checkerboard calibration sheet (printed, flat, high contrast)
• OpenPose/OpenCap/OpenSim software workflow (depending on your pipeline)
• Laptop for processing

Protocol

1. Camera Setup
    • Place two iPhones on tripods at different angles to the subject, ensuring both cameras have a clear view of the full movement.
    • Position cameras so they form a wide baseline (greater angle difference improves 3D reconstruction).
    • Set both iPhones to the same resolution and frame rate.
    • Align timestamps by starting recording at the same time or using a visible clap or jump for synchronization.

2. Calibration Using the Checkerboard
    • Place the checkerboard in the center of the capture space.
    • Ensure the checkerboard is clearly visible in both camera views.
    • Move the checkerboard slowly through the capture volume (left, right, forward, backward) while keeping it flat and facing the cameras.
    • Capture enough positions for the software to detect key calibration corners.
    • Stop recording and upload the calibration video into the software.
    • Run the calibration solver to determine camera intrinsics (focal length, lens distortion) and extrinsics (location and orientation).
    • Review the calibration quality score and redo calibration if error is large.

3. Recording the Movement Trial
    • Position the subject in the same calibrated volume used during checkerboard capture.
    • Start both iPhone recordings.
    • Have the subject perform the movement of interest.
    • Stop the recordings and transfer both videos to the computer.

4. Video Upload and 2D Pose Extraction
    • Upload both videos into the software pipeline (OpenCap, OpenPose, or custom workflow).
    • Run 2D pose detection to extract body keypoints frame-by-frame.
    • Inspect the tracked keypoints for drift or occlusions and correct any major issues.
    • Synchronize the two camera views using the clap marker or first frame of movement.

5. 3D Reconstruction
    • Use the software to triangulate the two 2D views into 3D joint positions.
    • Confirm that the reconstructed 3D skeleton appears anatomically correct and moves smoothly.
    • Export the reconstructed motion as a TRC (marker trajectory) file for OpenSim.

6. Importing Data into OpenSim
    • Open OpenSim and load a standard musculoskeletal model (e.g., Gait2392 or Rajagopal model).
    • Scale the model using subject anthropometric measurements or neutral pose frames.
    • Import the TRC file containing the 3D joint markers.
    • Run inverse kinematics (IK) to fit the model's joints to the marker trajectories.
    • Check IK error and adjust marker weights if needed.

       • Run inverse dynamics (ID) if ground reaction forces are available.
       • Export joint angles and other outputs for analysis.

Conclusions/action items:

This protocol outlines the full workflow from multi-camera setup and checkerboard calibration to 3D reconstruction and OpenSim analysis. Accurate calibration, synchronized recording, and clean 2D keypoint detection are the most important steps for generating reliable 3D joint kinematics.

11/30/2025 - Kinovea Data Analysis

KENNETH SUN - Dec 10, 2025, 8:04 PM CST

Title: Kinovea Data Analysis Results

Date: 12/10/25

Content by: Kenneth Sun
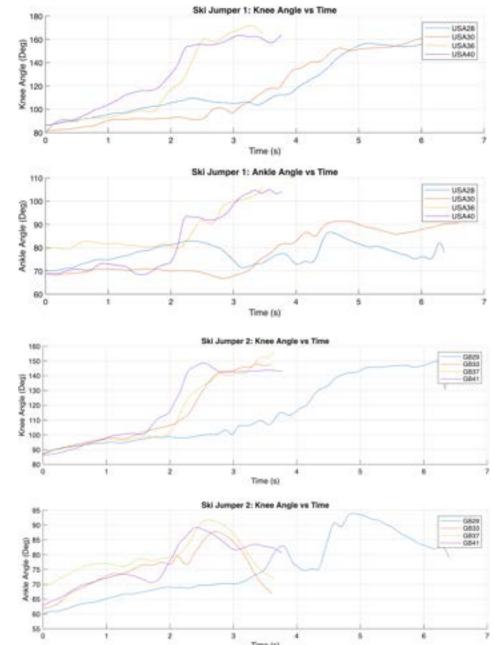
Present: Kenneth Sun

Goals: Graph and represent the kinovea body angles properly.

Content:

%% Kinovea Data Graph of USA and Green/Black Ski Jumpers

```matlab
close all;   % closes all open figures each time you run
clear all;
% Read in data for both ski jumpers
usa28 = readtable("/Users/ks14/Library/Mobile Documents/com~apple~CloudDocs/UW 25:26/BME design/usa28.knee.ankle.data.csv");
usa30 = readtable("/Users/ks14/Library/Mobile Documents/com~apple~CloudDocs/UW 25:26/BME design/usa30.ankle.knee.data.csv");
usa36 = readtable("/Users/ks14/Library/Mobile Documents/com~apple~CloudDocs/UW 25:26/BME design/usa36.knee.angle.data.csv");
usa40 = readtable("/Users/ks14/Library/Mobile Documents/com~apple~CloudDocs/UW 25:26/BME design/usa40.knee.ankle.data.csv");
bg29 = readtable("/Users/ks14/Library/Mobile Documents/com~apple~CloudDocs/UW 25:26/BME design/greenblack29.knee.ankle.data.csv");
bg33 = readtable("/Users/ks14/Library/Mobile Documents/com~apple~CloudDocs/UW 25:26/BME design/greenblack33.knee.angle.data.csv");
bg37 = readtable("/Users/ks14/Library/Mobile Documents/com~apple~CloudDocs/UW 25:26/BME design/greenblack37.knee.angle.data.csv");
bg41 = readtable("/Users/ks14/Library/Mobile Documents/com~apple~CloudDocs/UW 25:26/BME design/greenblack41.knee.ankle.data.csv");


%% USA Jumper (converted to vectors)
usa28_time       = usa28{:, "Time_ms_"};
usa28_knee_angle  = usa28{:, "KneeAngle"};
usa28_ankle_angle = usa28{:, "AnkleAngle"};


usa30_time       = usa30{:, "Time_ms_"};
usa30_knee_angle  = usa30{:, "KneeAngle"};
usa30_ankle_angle = usa30{:, "AnkleAngle"};


usa36_time       = usa36{:, "Time_ms_"};
usa36_knee_angle  = usa36{:, "KneeAngle"};
usa36_ankle_angle = usa36{:, "AnkleAngle"};


usa40_time       = usa40{:, "Time_ms_"};
usa40_knee_angle  = usa40{:, "KneeAngle"};
usa40_ankle_angle = usa40{:, "AnkleAngle"};


%% Green/Black Jumper (converted to vectors)
bg29_time       = bg29{:, "Time_ms_"};
bg29_knee_angle  = bg29{:, "KneeAngle"};
bg29_ankle_angle = bg29{:, "AnkleAngle"};


bg33_time       = bg33{:, "Time_ms_"};
bg33_knee_angle  = bg33{:, "KneeAngle"};
bg33_ankle_angle = bg33{:, "AnkleAngle"};


bg37_time       = bg37{:, "Time_ms_"};
```

```matlab
bg37_knee_angle  = bg37{:, "KneeAngle"};
bg37_ankle_angle = bg37{:, "AnkleAngle"};



bg41_time        = bg41{:, "Time_ms_"};
bg41_knee_angle  = bg41{:, "KneeAngle"};
bg41_ankle_angle = bg41{:, "AnkleAngle"};



%%% Convert USA time vectors to seconds
usa28_time = usa28_time / 1000;
usa30_time = usa30_time / 1000;
usa36_time = usa36_time / 1000;
usa40_time = usa40_time / 1000;



%%% Convert Green/Black time vectors to seconds
bg29_time = bg29_time / 1000;
bg33_time = bg33_time / 1000;
bg37_time = bg37_time / 1000;
bg41_time = bg41_time / 1000;



%%% Zero the time values for each jump
usa28_time = usa28_time - usa28_time(1);
usa30_time = usa30_time - usa30_time(1);
usa36_time = usa36_time - usa36_time(1);
usa40_time = usa40_time - usa40_time(1);



bg29_time  = bg29_time  - bg29_time(1);
bg33_time  = bg33_time  - bg33_time(1);
bg37_time  = bg37_time  - bg37_time(1);
bg41_time  = bg41_time  - bg41_time(1);



%%% ---- USA Knee Angle Plot ----
figure(1)
subplot(2,1,1);     % 2 rows, 1 column, top plot
hold on
plot(usa28_time, usa28_knee_angle);
plot(usa30_time, usa30_knee_angle);
plot(usa36_time, usa36_knee_angle);
plot(usa40_time, usa40_knee_angle);



title("Ski Jumper 1: Knee Angle vs Time");
xlabel("Time (s)");
```

```matlab
ylabel("Knee Angle (Deg)");
grid on
legend("USA28", "USA30", "USA36", "USA40");
hold off


%% ---- USA Ankle Angle Plot ----
subplot(2,1,2);     % 2 rows, 1 column, bottom plot
hold on
plot(usa28_time, usa28_ankle_angle);
plot(usa30_time, usa30_ankle_angle);
plot(usa36_time, usa36_ankle_angle);
plot(usa40_time, usa40_ankle_angle);




title("Ski Jumper 1: Ankle Angle vs Time");
xlabel("Time (s)");
ylabel("Ankle Angle (Deg)");
grid on
legend("USA28", "USA30", "USA36", "USA40");
hold off


%% ---- Green/Black Knee Angle Plot ----
figure(2)   % New figure for Green/Black group


subplot(2,1,1);     % Top plot
hold on
plot(bg29_time, bg29_knee_angle);
plot(bg33_time, bg33_knee_angle);
plot(bg37_time, bg37_knee_angle);
plot(bg41_time, bg41_knee_angle);




title("Ski Jumper 2: Knee Angle vs Time");
xlabel("Time (s)");
ylabel("Knee Angle (Deg)");
grid on
legend("GB29", "GB33", "GB37","GB41");
hold off


%% ---- Green/Black Ankle Angle Plot ----
subplot(2,1,2);     % Bottom plot
```

```
hold on
plot(bg29_time, bg29_ankle_angle);
plot(bg33_time, bg33_ankle_angle);
plot(bg37_time, bg37_ankle_angle);
plot(bg41_time, bg41_ankle_angle);




title("Ski Jumper 2: Knee Angle vs Time");
xlabel("Time (s)");
ylabel("Ankle Angle (Deg)");
grid on
legend("GB29", "GB33", "GB37","GB41");
hold off
```

Conclusions/action items:

Curve turned out well, the ski coach came to final presentation and mentioned the increase in slope of some of the jumps probably due to the athlete going into triple extension way too fast.

12/02/2025 - Force Insole Data Test

KENNETH SUN - Dec 10, 2025, 7:59 PM CST

Title: Force Insole Data Test Code and Graphs

Date: 12/10/25

Content by: Kenneth Sun
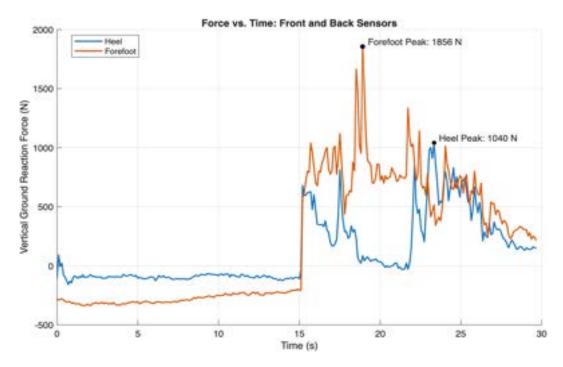
Present: Kenneth and Caleb

Goals: Record the experimentation results of our force insole force curves

Content:

The code below is the matlab code that takes CSV data from the WIFI user interface and transforms it into analyzable data for the coach to use.

```matlab
%% Select your athlete's data file
% Choose the CSV file you downloaded from the insoles.



close all;
clear all;
[file, path] = uigetfile('*','Select the file to open');
raw = importdata([path, filesep, file]);



%% Convert time into seconds
% The time column is in milliseconds; this changes it to seconds
% and starts the clock at 0.
```
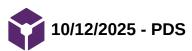
```matlab
time_ms = raw.data(:,1);
time_s  = (time_ms - time_ms(1)) / 1000;
```

```matlab
%% Load heel and forefoot force data
% These columns represent force under the heel and forefoot.
```

```matlab
p1_back  = raw.data(:,5);   % Heel
p5_front = raw.data(:,6);   % Forefoot
```

```matlab
%% Clean the force signal
% Uses the start of the recording to remove baseline noise
% and flips the signal so force increases upward on the graph.
```

```matlab
nBaseline = min(100, length(p1_back));
p1_inverted = -(p1_back  - mean(p1_back(1:nBaseline)));   % Heel
p5_inverted = -(p5_front - mean(p5_front(1:nBaseline)));  % Forefoot
```

```matlab
%% Find the peak forces
% Identifies the highest force for both heel and forefoot.
```

```matlab
[peakHeel,idxHeel] = max(p1_inverted);
[peakForefoot,idxForefoot] = max(p5_inverted);
```

```matlab
timeHeelPeak = time_s(idxHeel);
timeForePeak = time_s(idxForefoot);
```

```matlab
%% Plot the force curves
% Displays force over time for heel and forefoot.
```

```matlab
figure;
hold on;
plot(time_s, p1_inverted, 'LineWidth', 1.5);
plot(time_s, p5_inverted, 'LineWidth', 1.5);
```

```matlab
%% Mark the peak points on the graph
% Adds marker to show where the max forces occurred.
```

```
plot(timeHeelPeak, peakHeel, 'o', 'MarkerSize', 5, 'MarkerFaceColor', 'k');
plot(timeForePeak, peakForefoot, 'o', 'MarkerSize', 5, 'MarkerFaceColor', 'k');


%%% Label the peak force values
% Displays the numeric value of each peak on the graph.


text(timeHeelPeak, peakHeel, ...
    sprintf('  Heel Peak: %.0f N', peakHeel), ...
    'VerticalAlignment', 'bottom');


text(timeForePeak, peakForefoot, ...
    sprintf('  Forefoot Peak: %.0f N', peakForefoot), ...
    'VerticalAlignment', 'bottom');




%%% Add graph labels
% Makes the graph easier to understand.


legend('Heel', 'Forefoot', 'Location', 'best');
title("Force vs. Time: Front and Back Sensors");
xlabel("Time (s)");
ylabel("Vertical Ground Reaction Force (N)");
grid on;
```

Conclusions/action items:
Curve takes into account forefoot dominant jumping technique and reflects the three trial jumps performed in the testing.

10/12/2025 - PDS

Matthew Niemuth - Oct 12, 2025, 3:56 PM CDT

Matthew Niemuth - Oct 12, 2025, 3:49 PM CDT

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Product_Design_Specification.pdf (370 kB)

10/12/2025 - Preliminary Design Presentation

Matthew Niemuth - Oct 12, 2025, 3:56 PM CDT

Matthew Niemuth - Oct 12, 2025, 3:56 PM CDT

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F25_Preliminary_Presentation.pdf (2.63 MB)

10/12/2025 - Preliminary Report

Matthew Niemuth - Oct 12, 2025, 3:57 PM CDT

Matthew Niemuth - Oct 12, 2025, 3:58 PM CDT

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Preliminary_Report.pdf (1.93 MB)

12/05/2025 - Final Poster

CALEB WHITE - Dec 08, 2025, 1:37 PM CST

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CalebWhite-SkiJumpBME_1_.png (1.94 MB)

12/10/2025 - Final Report

CALEB WHITE - Dec 10, 2025, 10:58 PM CST

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BME_200_300_-_Ski_Jump_Final_Report.pdf (4.52 MB)

9/12/2025 - Key transition technology of ski jumping based on inertial motion unit, kinematics and dynamics

CALEB WHITE - Sep 12, 2025, 3:22 PM CDT

Title: Key transition technology of ski jumping based on inertial motion unit, kinematics and dynamics

Date: 9/12/2025

Content by: Caleb White

Goals: Understand the physics and biomechanics involved with ski jumping. See what the points of focus when proper technique is involved and understand how these concepts and ideas can be applied to the analysis of ski jumpers in this project, specifically when observing the professional and then translating it down into a teachable format.

Search Term: Ski Jumping

Citation: Yu J, Ma X, Qi S, Liang Z, Wei Z, Li Q, Ni W, Wei S, Zhang S. Key transition technology of ski jumping based on inertial motion unit, kinematics and dynamics. Biomed Eng Online. 2023 Mar 2;22(1):21. doi: 10.1186/s12938-023-01087-x. PMID: 36864414; PMCID: PMC9983218.
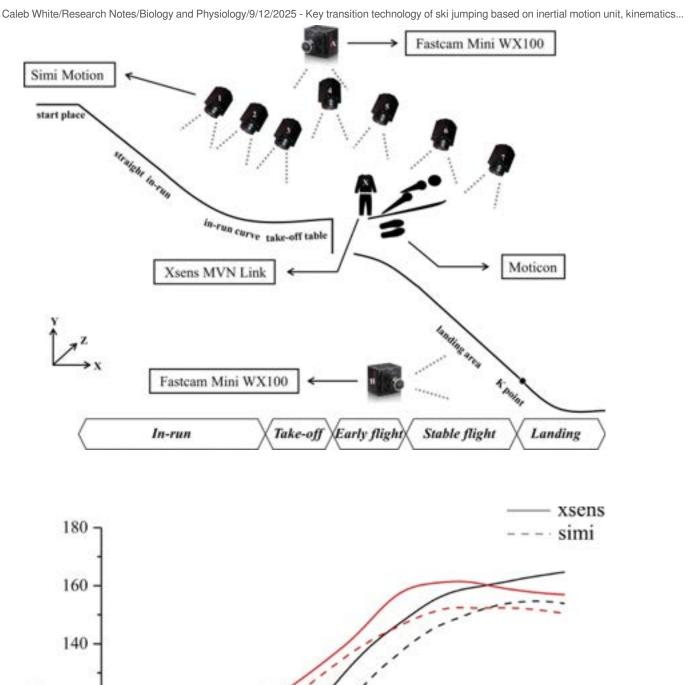
Link: https://pmc.ncbi.nlm.nih.gov/articles/PMC9983218/
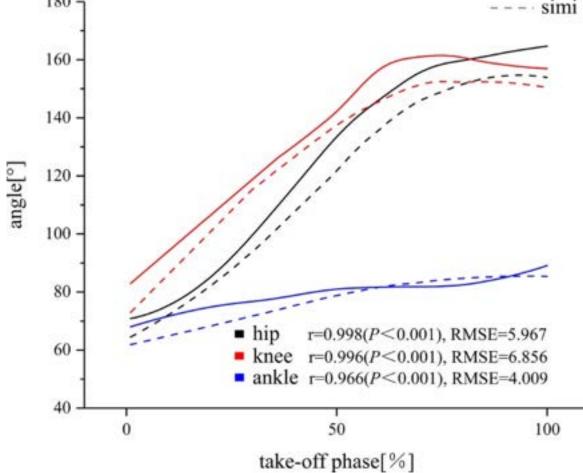
Content:
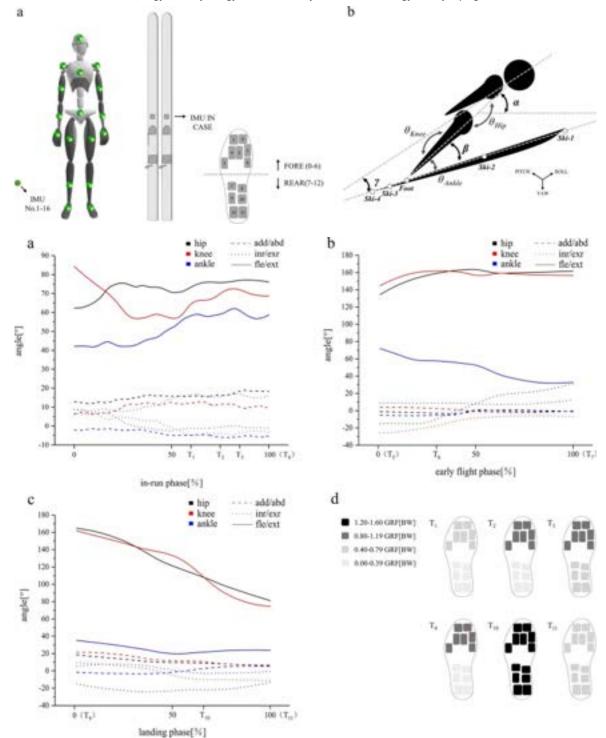
This study aims to evaluate a measurement system (i.e. the merging of 2D video recording, inertial measurement unit and wireless pressure insole) that can capture a wide range of sport performance and focus on the key transition technical characteristics.

The application validity of the Xsens motion capture system in ski jumping was verified under field conditions by comparing the lower limb joint angles of eight professional ski jumpers during the takeoff phase collected by different motion capture systems (Xsens and Simi high-speed camera). Subsequently, the key transition technical characteristics of eight ski jumpers were captured on the basis of the aforementioned measurement system.

In an outdoor experiment, eight ski jumpers were equipped with an IMU-based motion capture suit with 17 sensors and wireless pressure insoles. Each IMU consisted of a 3D linear accelerometer, a 3D rate gyroscope and a 3D magnetometer. Each insole was composed of 13 pressure sensors with a measuring range of 0–50 N/cm^2. Climatic and environmental parameters were collected by a multifunctional weather station and a snow pack analyser.

The test conditions on the hill did not allow for 3D measurements, and thus 2D video recordings parallel to the sagittal plane were used. In the study design, seven Simi Motion high-speed cameras were selected and placed side by side on the table to record the technical movements of the ski jumpers in a long distance. Two Fastcam Mini WX100 high-speed cameras were set up on one side of the takeoff table and landing area to focus on capturing the takeoff posture and landing buffer action of the ski jumpers. Meanwhile, the athletes wore Xsens suit and Moticon insole, and additionally, one IMU was placed on each of the two skis. The captured videos were stored on computer hard disk, and the Xsens and insole data were stored offline.

On the basis of the biomechanical measurement system established in the study, the transition process of key technologies in ski jumping is analysed as follows. In the straight area, athletes can achieve a streamlined posture of 'rolling up' by stretching the shoulder, elbow and wrist joints to the rear of the body, and then pressing them close to both sides of the body, followed by flexing the hip, knee and ankle joints, and finally, leaning forward to lower the centre of gravity. This posture meets the requirements of fluid mechanics and can minimise air resistance.

In the straight area, the size of the GRF of athletes remains nearly unchanged, and the body is under a static condition of low load, which is the result of the dynamic balance between the opposing and positive torques. Centripetal force will be generated after entering the entrance of the arc area

Conclusions/action items:

The combination of 2D high-speed video recording, IMU and wireless pressure insole can capture the sports performance of ski jumpers within a large range in the outdoor field without affecting the athletes' execution of technical actions. The research results prove that the measurement system is effective and exhibits certain application prospect. The established measurement system can effectively capture the key transition technical characteristics of ski jumpers whilst observing the overall movement stage, particularly the dynamic changes of the straight turn into arc in inrun, the adjustment of body posture and ski movement in early flight and landing preparation.

Researchers should give more attention to the key transition technologies of ski jumping, and further research should focus on the effects of these key transition technologies on the sports performance of ski jumpers. Athletes and coaches should place importance on key transition technologies and conduct special training in accordance with different technical needs to improve the sports performance of athletes.

CALEB WHITE - Sep 26, 2025, 11:39 AM CDT

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KeyTransitionDoc.pdf (1.64 MB)

9/15/2025 - Performance Analysis in Ski Jumping with a Differential Global Navigation Satellite System and Video-Based Pose Estimation

CALEB WHITE - Sep 15, 2025, 9:16 PM CDT

Title:

Performance Analysis in Ski Jumping with a Differential Global Navigation Satellite System and Video-Based Pose Estimation

Date: 9/15/2025

Content by: Caleb White

Goals: Investigate an alternative method of ski jump analysis in terms of the physics associated with the action. Form parallels between this form of measurement and others researched as well as parallels between the deemed 'important' characteristics of the jump, and what should be looked out for.

Search Term: Performance Ski Jumping System

Citation:

[1] O. Elfmark *et al.*, "Performance Analysis in Ski Jumping with a Differential Global Navigation Satellite System and Video-Based Pose Estimation," *Sensors*, vol. 21, no. 16, p. 5318, Jan. 2021, doi: 10.3390/s21165318.

Link: Performance Analysis in Ski Jumping with a Differential Global Navigation Satellite System and Video-Based Pose Estimation

Content:

This study investigated the explanatory power of a sensor fusion of two complementary methods to explain performance and its underlying mechanisms in ski jumping. A differential Global Navigation Satellite System (dGNSS) and a markerless video-based pose estimation system (PosEst) were used to measure the kinematics and kinetics from the start of the in-run to the landing.

The study had two aims; firstly, the agreement between the two methods was assessed using 16 jumps by athletes of national level from $5\,\mathrm{m}$ before the take-off to $20\,\mathrm{m}$ after, where the methods had spatial overlap. The comparison revealed a good agreement from $5\,\mathrm{m}$ after the take-off, within the uncertainty of the dGNSS ($\pm0.05\,\mathrm{m}$). The second part of the study served as a proof of concept of the sensor fusion application, by showcasing the type of performance analysis the systems allows. Two ski jumps by the same ski jumper, with comparable external conditions, were chosen for the case study. The dGNSS was used to analyse the in-run and flight phase, while the PosEst system was used to analyse the take-off and the early flight phase. The proof-of-concept study showed that the methods are suitable to track the kinematic and kinetic characteristics that determine performance in ski jumping and their usability in both research and practice.
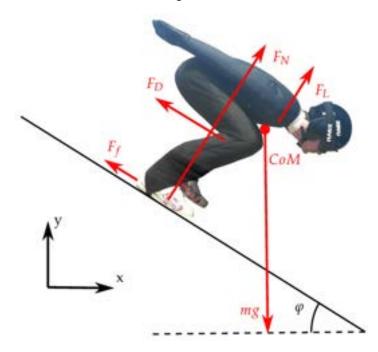
Performance in ski jumping is quantified in terms of distance from take-off, adjusted for style, start gate and wind conditions. The jump distance is influenced by a variety of factors, such as in-run speed, vertical speed produced in the take-off, wind conditions and the aerodynamics during the flight phase [2]. The current literature considers the take-off to be the most important phase [1,2,3]. A ski jump is commonly analysed by relating the performance outcome to in-run speed (measured with photocells before take-off) together with a qualitative assessment of performance-determining factors during take-off and the early flight phase, using video analysis. Video is typically captured by coaches and the analysis is of a qualitative nature

Establishing valid measurements of the aspects that impact performance in ski jumping from the start of the in-run to the landing is challenging, as athletes move through a large space, at high speed, in outdoor conditions (variable weather conditions and surroundings). Therefore, many scientific studies have focused on the take-off phase [1,2,3]. For that purpose force plates were mounted under the in-run track to measure the take-off force and timing [10,11,12], and pressure insoles were used to measure force both at take-off and landing [13,14,15]. A force plate has the advantage that it can be used without interfering with the athlete. It can therefore be used in competition, but the data

are limited to only the last part of the in-run and the take-off (~ 10 m) [1]. Pressure insoles, on the other hand, cannot be used in competition but allow the extraction of data from the complete in-run and take-off phase, including parameters such as flight time and data from the landing phase

The stable flight phase is a commonly used term in ski jumping literature, referring to the aerial phase where the ski jumper has reached a fairly constant flight position, and which lasts until the landing starts. It is worth noting that the term 'stable' is misleading since the state of stability is irrelevant. From a physics point of view, this phase should be described as 'isometric-static'; i.e., acceleration of some key parameter equals zero (some forces seem in balance), and so is the velocity of these parameters.

A dGNSS is used to describe the kinematics and kinetics from start of the in-run to the landing, while a PosEst system is used to describe kinematics and kinetics of the take-off and early flight phase using a body segment model. Accordingly, the aim of the study is twofold: firstly, we addressed the agreement between these two methods in a region where both are assumed to be accurate. Secondly, we illustrated the strength a combination of these two methods can provide in performance analysis. In Part I, the two methods were applied to compare measured trajectories and estimated velocities and accelerations in 16 ski jumps. The data sets were collected simultaneously, time synchronized and the systems agreement was assessed during the early flight phase, where the dGNSS is assumed to be valid. Part II served as a proof of concept of the sensor fusion application by showcasing the type of performance analysis that can be conducted with the systems. For that purpose two jumps, from the same ski jumper and with comparable wind conditions, were chosen. The trajectories, their derived variables and performance outcomes were evaluated against literature data.

During the in-run, the normal force will have a substantial increase when the ski jumper is entering the curved section

due to the centrifugal force and the normal force can be formulated as: $= (\cos(휀) + v^2 / r)$ where m is the skier's

mass, g the gravitational acceleration, v the relative velocity and r the radius of the curve. The aerodynamic forces are defined as acting parallel (drag) and perpendicular (lift) to the direction of relative motion [44], and are defined as

$$= 1/2\, \rho\, v\,{}^2 C_d A \tag{2}$$

and

$$= \tfrac{1}{2} \rho \quad {}^2 \quad , \tag{3}$$

where   is the air density, v the relative velocity, A the frontal area of the object and   and   the drag and lift coefficients.

Conclusions/action items:

The two different types of measurement system are not in much agreeance for the first 5m of the jump, but following this going into the take off phase there is much more agreeance. A selection of preferred or combination method could be made for the project. The use of the motion capture system would much more resemble the PosEst method but the convenience of the dGNSS method should be looked further into. The kinematic and kinetic considerations in the study should be resembled for the purposes of the project.

CALEB WHITE - Sep 26, 2025, 11:40 AM CDT

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sensors-21-05318.pdf (10.8 MB)

9/14/2025 - MOTICON Foot Sensors

CALEB WHITE - Sep 14, 2025, 4:57 PM CDT

Title: MOTICON Foot Sensors

Date: 9/14/2025

Content by: Caleb White

Goals: Understand the technology of foot pressure sensors and their potential project implementations. Learn how the group can implement such sensors and then begin to discover how this idea fits in to the overall broader scope of project.

Search Term: Foot Pressure Sensors

Citation:

[1] "Sensor insoles for clinical grade mobile gait & motion analysis." Accessed: Sept. 14, 2025. [Online]. Available: https://moticon.com/
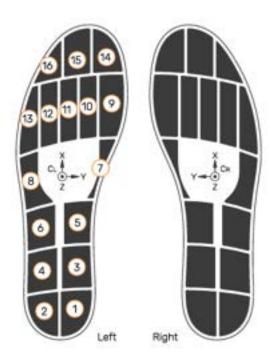
Link: Sensor insoles for clinical grade mobile gait & motion analysis

Content:

The insoles have 16 pressure sensors, 3 accelerometers, and 3 angular rate sensors per side.

The product contains Bluetooth capabilities powered by a PD2032 con cell battery, rechargeable

The product comes in 9 sizes and contains an onboard data chip for memory and live data transmission to a mobile device.

Notes

The sensor insole outline and the sensor positions are given in a common coordinate system. The orientation of the coordinate systems is different for left and right sides.

Legend

① Sensor numbering
x/y/z Directions of coordinate system
C₀₀ Center of coordinate system

The insoles have a plethora of operational modes to be utilized:

Operation Modes

Standard Modes [1]	Description	Use Case
Preview	Transmits fixed basic sensor data wirelessly	Live showcasing and activity checks in the OpenGo App
Live	Transmits sensor data wirelessly to endpoint (desktop computer)	Direct data transmission for storage on endpoint
Record	Sensor data recording on onboard memory	Standalone data acquisition without mobile phone or tablet
Transmit	Wireless sensor data transmission from onboard memory to endpoint	Transfer of previously recorded sensor data to endpoint for storage on endpoint
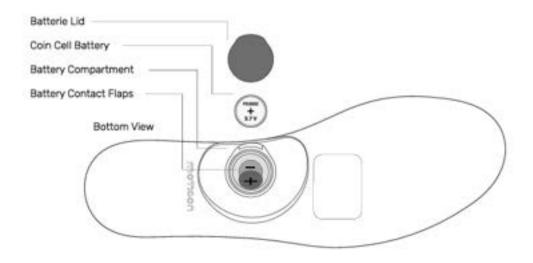
Intelligence Modes [1]	Description	Use Case
Smart Recording [2]	Activity triggered recording mode. Recording is only resumed when user is active [load, motion]	Longterm gait monitoring
Smart Sleep	Automatic shutdown into power safe mode when sensor insole is not in use. No hardware switch.	No user interaction for turning on/off required

Notes

[1] The operation modes can be selected in the OpenGo App.
[2] Smart Recording is an activity triggered recording mode where internal firmware algorithms control the intermediate pausing and resuming in action. The mobile device (phone/tablet) is only required for starting and stopping, not for the recording itself. For further details on the operation modes refer to the product pages on moticon.com/opengo/app.

Supply Voltage	Power Consumption	Battery [1] Type	Battery Form Factor	Battery Technology
3.7 v ± 0.4 v	varies based on operation mode	1 coin cell rechargeable	2032	Lithium Ion

Batterie Lid

Coin Cell Battery

Battery Compartment

Battery Contact Flaps

Bottom View

Wireless Standard	Profile	Wireless Range	Bandwidth
BLE 5.0 [1]	proprietary [2]	≥ 10.0 m [3]	54 kB/s [4]

Data Volume	Download Time [5]	Recording Equivalent [5]
28.80 MB [6]	00:08:54 hh:mm:ss	68 min @ 100 Hz Full Setup
4.30 MB	00:01:20 hh:mm:ss	10 min @ 100 Hz Full Setup
0.43 MB	00:00:08 hh:mm:ss	1 min @ 100 Hz Full Setup

Notes

[1] Version refers to integrated wireless chip. BLE connection to smartphones can be established from version 5.0.
[2] No standard BLE profile is used.
[3] Depends on environmental conditions and other active wireless devices.
[4] Maximum data transmission bandwidth. Depends on smartphone performance.
[5] Given times and setups are estimates and shall illustrate expectable download times of previously on-board recorded sensor data to a smartphone using the OpenGo App.
[6] Includes 10 % overhead for auxiliary data.

Conclusions/action items: The MOTICON OpenGo-Sensor-Insoles are the perfect device for tracking volume and distribution of force during a specific action. The device uses a plethora of internal sensors that are hooked up to a chip which communicates to its online interface via Bluetooth. The device would be perfect for a project such as this but of course is extremely expensive and not a feasible option. I think because of the scenario in which a force sensor is desired to be used, it makes the most sense to go further with an idea such as this.

09/8/2025 - The analysis of infrared high-speed motion capture system on motion aesthetics of aerobics athletes under biomechanics analysis

CALEB WHITE - Sep 12, 2025, 3:22 PM CDT

Title: The analysis of infrared high-speed motion capture system on motion aesthetics of aerobics athletes under biomechanics analysis

Date: 09/08/2025

Content by: Caleb White

Goals: Begin to develop an understanding of motion capture and its application in biomechanic settings. See how movement can be analyzed and understood through motion capture and the capabilities of understanding these force relationships can have on learning and teaching movement.

Search Term: 'motion capture biomechanics'

Citation: Qiu Y, Guan Y, Liu S. The analysis of infrared high-speed motion capture system on motion aesthetics of aerobics athletes under biomechanics analysis. PLoS One. 2023 May 25;18(5):e0286313. doi: 10.1371/journal.pone.0286313. PMID: 37228162; PMCID: PMC10212154.
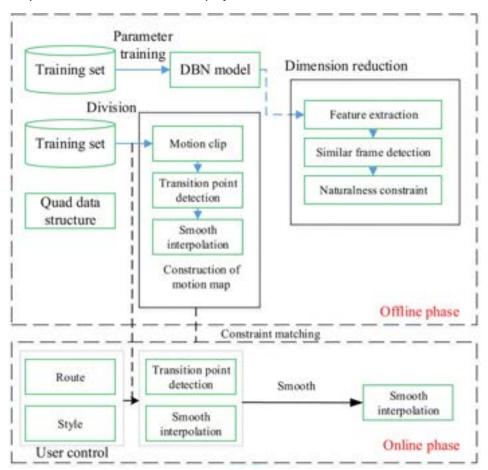
Link: [The analysis of infrared high-speed motion capture system on motion aesthetics of aerobics athletes under biomechanics analysis - PMC](#)
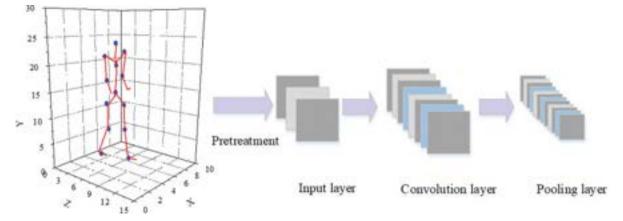
Content:

- This paper uses an infrared high-speed motion capture system based on deep learning to analyze difficult movements, which helps aerobics athletes master difficult movements more accurately. Firstly, changes in joint angle, speed of movement, and ground pressure are used to analyze the impact and role of motion fluency and completion based on a biomechanical perspective. Moreover, based on the existing infrared high-speed motion capture systems, the Restricted Boltzmann Machine model is introduced to construct an unsupervised similarity framework model. Next, the motion data is reorganized based on three-dimensional information to adapt to the model's input.

- The framework performs similar frame matching to obtain a set of candidate frames that can be used as motion graph nodes. After the infrared high-speed motion capture system and inertial sensors are simultaneously applied to subjects, the multi-correlation coefficients values of the hip, knee, and ankle angles are 0.94 ± 0.06, 0.98 ± 0.01, and 0.87 ± 0.09, respectively. The two systems show a high degree of correlation in the measurement results, and the knee joint is the most significant correlation. Finally, a motion graph is constructed to control its trajectory and adjust its motion pattern. The infrared high-speed motion capture system optimized for deep learning can extract features from human bone data and capture motion more accurately, helping trainers to fully understand difficult movements.

- Infrared motion capture technology provides powerful data support for traditional empirical training, making the process more efficient. By capturing and analyzing athletes' data, coaches can more accurately identify differences and guide students to correct and optimize. The parameters of human functional movement are important indexes to evaluate the corresponding movements such as walking, running, jumping, and squatting. Based on three-dimensional key points and bones, ordinary cameras achieve full-body driving of virtual images. The camera can track even if the character has significant movement changes, occlusion, turning, and other situations. As an analytical instrument used in the field of sports science, the infrared motion capture system uses a high-performance infrared lens to capture passive luminous marking points to construct a 3D movement acquisition and analysis system. In addition to sports motion analysis, the infrared motion capture system is widely used in gait rehabilitation, motion analysis, robots, drones, movie animation, game production, virtual simulation, and other fields.

- Infrared motion capture technology can provide powerful data support for traditional experience-based training, making the training process more efficient. Existing research has confirmed that capturing and analyzing the movement data of the world's top athletes can more accurately compare and judge the gaps in training movement. Therefore, the athletes can be guided to optimize their movements.

- Sports biomechanics plays an important role in sports development, especially in technical analysis, training, design and improvement of sports equipment, and prevention of athlete injuries. The research of sports biomechanics provides support for the development of rehabilitation engineering. The demand and progress of rehabilitation engineering have promoted the research and development of sports biomechanics. The rehabilitation of sports injuries depends on the

comprehensive application of biology, sports means, and mechanics. Sports biomechanics can provide a complete perspective. The high-difficulty jumping movements in sports aerobics have five characteristics. 1. The entire movement is completed in the air. There are one or more aerial movements. 3. The duration of air motion during the entire air process is long. The degree of rotation in the air determines the score of the same difficult action. These trends are homogenous to a ski jump due to the fast based aerial body control that is required for the task.

- The infrared high-speed motion capture system uses a high-speed infrared camera to capture passive luminous marker points and constructs a 3D motion acquisition and analysis system. Due to the extremely rapid changes in motion trajectory, it is difficult for humans to recognize every subtle movement with the naked eye. During whole-body exercises, at most, more than 400 muscles will work simultaneously. It is very challenging for students to quickly judge the biomechanics involved in each small movement. Motion capture technology visualizes sports movements so students can observe them more clearly and obtain data reference. This technology could be a huge help to sports research and education. The motion capture system composed of cameras can record the motion trajectory of multiple passive marker points. As a result, it can capture and record the whole body's motion trajectory and select the marked parts according to the needs.

- The infrared motion capture system requires multiple cameras. It uses a 16-megapixel camera to fuse video animation with space to obtain 3D coordinates for landmarks. After the collected motion data is processed by related software, the complete 3D bone structure is displayed.

Conclusions/action items: The use of motion capture from a biomechanical perspective has erupted in recent times due to developing technology that allows for the precise analyzation of movement and force distribution across a multi-part body. The use of complex aerobic activity in this paper gives a direct display of how this technology can be used for ski jump applications due to the direct parallels of difficult aerial forms. Further research needs to be done into the motion capture at the UW-Madison campus. It is currently unknown if that camera is infared. If so, further parallels can be drawn and the paper can be further used for its overall approach to tracking the moevement, specifically through dot movement.

CALEB WHITE - Sep 26, 2025, 11:41 AM CDT

[Download](#)

infaredmotioncapture.pdf (2.54 MB)

09/28/2025 - Kinovea

CALEB WHITE - Sep 28, 2025, 8:25 PM CDT

Title: Kinovea

Date: 09/28/2025

Content by: Caleb White

Goals: Learn the capabilities of the Kinovea software and brainstorm how it can be implemented into the project

Search Term: Kinovea

Citation:

[1] "Kinovea." Accessed: Sept. 28, 2025. [Online]. Available: https://www.kinovea.org/download.html

Link: Kinovea

Content:

Kinovea is a video annotation tool designed for sport analysis

It features utilities to capture, slow down, compare, annotate, and measure motion in videos

Kinovea is organized around four core missions related to studying human motion: capture, observation, annotation and measurement.

Time in Kinovea can be represented in various units like the frame number, the total milliseconds since start, or a classic timecode format.
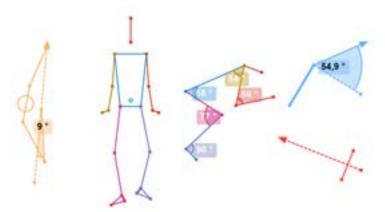
For videos that are already in slow motion because they have been captured with a high speed camera, the scale of time can be adjusted to the capture framerate and all times across the program will then reflect real time values.

Advanced tools can be created from scratch using a powerful custom tool framework.

These are XML files describing the list of points, lines, angles and how the tool should behave when the user interacts with it.

Many of the more advanced tools found in Kinovea like the bike-fit, archery or human model tools are actually custom tools that you can copy and modify to suit your needs.
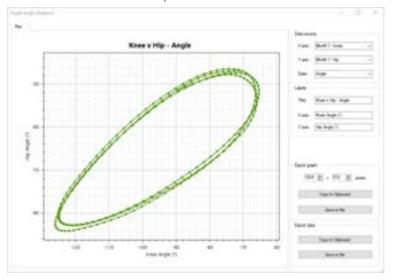
Custom tools can have tracked points, computed points, distances and angles measurements, visibility menus, styling and colors and other goodies.

Measure time spans using the chronometer and distances and angles using the line, angle and goniometer tools.

You can zoom in to increase precision, measurements are done with subpixel accuracy.

Visualize angle-angle diagrams to determine joints dynamics during motion.
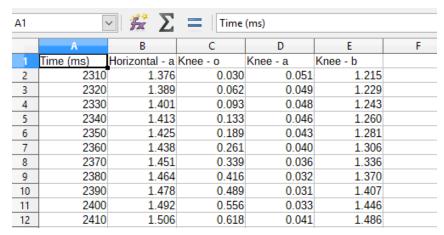
The main interface can be configured for a single camera, two cameras or one camera and one playback screen.

You can run several instances of Kinovea simultaneously on the same computer if you need to capture more than two cameras at the same time or have a more advanced setup.

Annotations can also be painted permanently on the video frames and new videos exported.

Other export options allow to save the individual frames or key images to separate files, create video slideshows and create videos with pauses on key images.

When using the dual playback screen configuration, a video containing the synchronized frames composited together can be exported.

A1				Time (ms)		
	A	B	C	D	E	F
1	Time (ms)	Horizontal - a	Knee - o	Knee - a	Knee - b	
2	2310	1.376	0.030	0.051	1.215	
3	2320	1.389	0.062	0.049	1.229	
4	2330	1.401	0.093	0.048	1.243	
5	2340	1.413	0.133	0.046	1.260	
6	2350	1.425	0.189	0.043	1.281	
7	2360	1.438	0.261	0.040	1.306	
8	2370	1.451	0.339	0.036	1.336	
9	2380	1.464	0.416	0.032	1.370	
10	2390	1.478	0.489	0.031	1.407	
11	2400	1.492	0.556	0.033	1.446	
12	2410	1.506	0.618	0.041	1.486	

Conclusions/action items:

Kinovea could prove to be a very useful software for the project. The team really wants to attempt to find the correct software so we can begin testing with it. Kinovea is 1 of 3 main choices that the team has discussed. It's advantages come with it's abilities to accept slow motion videos as well as interpret or slow down live videos. A fear for the other applications is that the ski jump motion may be too fast to detect accurate data.

09/28/2025 - Dartfish

Title: Dartfish

Date: 09/28/2025

Content by: Caleb White

Goals: Learn the Dartfish software and see if it has any valuable capabilities that can be used in the groups project.

Search Term: Dartfish

Citation:

[1] "Motion analysis solutions from Dartfish to analyze movements.," Dartfish. Accessed: Sept. 28, 2025. [Online]. Available: https://www.dartfish.com/motion/

Link: Dartfish | Video Analysis Solutions to Improve Teams' & Athletes' Performance

Content:

Dartfish is another motion capture software the specializes in athlete performance across a multitude of different sports, including skiing. It is the most mainstream form of video analysis software for athletes in the professional scene and is used heavily for applications similar to that of this project.

They work in demonstrating how to execute technical protocols correctly, to improve athletic performance, to help athletes avoid and prevent injuries, to rehabilitate injured athletes and facilitate a safe recovery and return to action.

Simply use a smartphone or tablet easily film a physiotherapy session.

Save for viewing later, the exercise being performed, while continuing to record the performance live.

Use advanced replay tools such as slow-motion, frame-by-frame, and zoom to examine the movement in detail

Compare movements by overlaying images, comparing them side-by-side and/or from different angles simultaneously

Track movements and trajectories to highlight technique differences

Compare performances between athletes with SimulCam

Breakdown and analyze the key positions of a movement with StroMotion

The software does cost money however which should be considered when deciding if this is the correct choice for the project.

Conclusions/action items: Dartfish seems a very solid software choice for the project. In comparison to OpenCap, it has slow motion capabilities which is very nice but so does Kinovea. It is hard to distinguish their specific capabilites as they seem quite similar. Dartfish does require some level of subscription in order to use which would eat into the project budget. The budget is large but I think it would be best to limit spending as much as possible. I think that the team should test out the other two free software, OpenCap and Kinovea, first and then determine if they do not have the capabilities that we desire, in which Dartfish can be purchased and tried.

10/12/2025 - The Perfect Jump

CALEB WHITE - Oct 12, 2025, 4:35 PM CDT

Title: The perfect jump

Date: 10/12/2025

Content by: Caleb White

Search Term: The perfect ski jump

Citation:

Link:

1998 Perfect Score: Bing Videos

2022 Beijing Olympics: Ski Jumping - Men's Individual Large Hill Final | Full Replay | #Beijing2022

Goals: Find the metric values we have chosen that were performed on perfect or near perfect jumps.

Content:

Because of the subjective and qualitative nature of scoring, comparative metric values need to be determined to match the youth athletes against. This will be done by looking at ski jumps that have received very good scores and identifying their values. There have only been two perfect scores in the history of ski jumping. One in 1976 and one in 1998. Because these were relatively long ago, the footage is not great, and it would be difficult to find actual values from these recordings. Instead, recent footage from the Beijing 2022 Olympics will be used to identify the correct values.

Conclusions/action items:

Unfortunately, because of the rareness of perfect 20/20 style ski jumps, there is not sufficient recorded evidence to support actual quantitative values for a perfect score. Because of this, basic professional values will have to be determined.

Accelerometer (IMU) Design

CALEB WHITE - Sep 26, 2025, 5:27 PM CDT

Title: Accelerometer (IMU) Design

Date: 09/26/2025

Content by: Caleb White
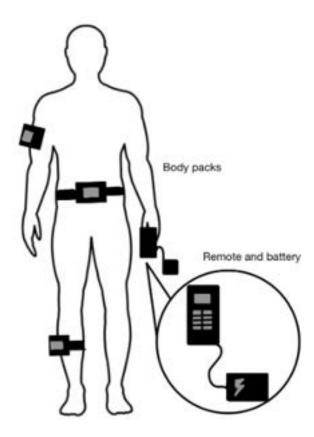
Present: N/A

Goals: Design an accelerometer or IMU based data system that could feasibly be an option for the project.

Content:

The Accelerometers (IMUS) design is based around the use of various Inertial Measurement Units that would look to provide high-frequency motion data, with a specific focus on acceleration, angular velocity, and spatial relation. Several small IMU devices would be placed on the user in several specific locations dictated by an associating machine learning software. These locations would be easy to reach, practical, and relevant locations on the body such as the left foot, right shoulder, and waist. The IMU's would be a part of a larger circuit that would involve a central microcontroller functioning both as a voltage distributor and as a processing hub for the raw data being recorded by the IMUs, as well as a battery for voltage supply. These two components would be placed on the waist, along with one of the IMU's. This design ranked in the middle of the three designs in terms of overall score due to a specific lack of feasibility and a general difficulty with reliable data capture.

Conclusions/action items:

This design is an accelerometer-based data capturing device that looks to combine with a microcontroller and software to provide feedback to the user based on their speed and positioning. An important distinction here is the placement of the accelerometers around various parts of the body. This design is very solid in theory but in general lacks the potential for actual application due to the number of items needed to be worn by the user.

Force Plate Insoles

CALEB WHITE - Sep 26, 2025, 5:37 PM CDT

Title: Force Plate Insoles

Date: 09/26/2025

Content by: Caleb White
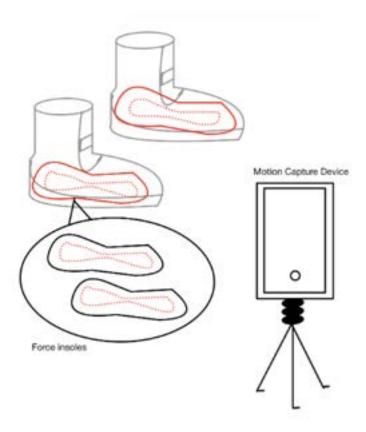
Present: N/A

Goals: Design a way to track force data from the user without being to invasive or intruding on their individual or process during the ski jump.

Content:

The design of the force plate and motion capture is centered around having force plate insoles in the skier's shoes. These force plates are portable devices that we would manually place in the soles of the ski boots. The motion capture aspect of the design would record 3D body images and segments of movement during the jump. This would include the angles of the body, the velocity of the jump, and the kinematics of the takeoff. The motion capture device would be a compact camera or mobile device suitable for outdoor usage, and would be placed directed towards the side view of the jump/jumper.

Conclusions/action items:

The design combines the use of force plate insoles with motion capture to make a comprehensive system that focuses on a few very important distinct independent variables. The design shown above was the one chosen by the design team for the design matrix.

Velostat Testing

CALEB WHITE - Oct 23, 2025, 12:01 PM CDT

Title: Velostat Testing

Date: 10/23/2025

Content by: Caleb White

Present: Caleb White

Goals: Understand the Velostat and its tendencies as a material and formulate an appropriate way it can be implemented into the force plate design

Content:

The whole purpose of this was to understand Velostat and begin to find an actual and feasible way to implement the Velostat into the force plate design.

I began by creating a simple voltage divider circuit and tracked the Velostat resistance change through Arduino IDE. I then played around with how it responded to my touch. From this I layered the Velostat to increase total resistance and observed a larger change with an associating pressure, increasing the sensitivity of the system and giving a broader range of pressure determination.

```
const int analogPin = A0;

//const int threshold = 700;


void setup() {

  Serial.begin(9600);

  //pinMode(13, OUTPUT);

  //pinMode(7, OUTPUT)

}


void loop() {

  int analogValue = analogRead(analogPin);

  Serial.println(analogValue);

  float voltageValue = analogValue * (5.0 / 1024.0);

  Serial.println(voltageValue);
```

```
float resistance = (50/voltageValue) - 10;


Serial.println(resistance);
```

Image preview

Conclusions/action items:

By layering the Velostat there is a decrease in resistance as the material is being compressed. One lead is attached to the top piece and the other to the bottom. This forces the current to travel through the multiple layers of Velostat in order to continue the circuit. The system was actually quite responsive and seems like something that could be used in the system.

Insole Testing

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items:

10/14/2025 - Kinovea Training

Title: Kinovea Training

Date: 10/14/2025
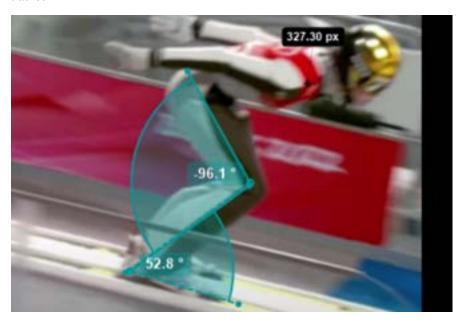
Content by: Caleb White
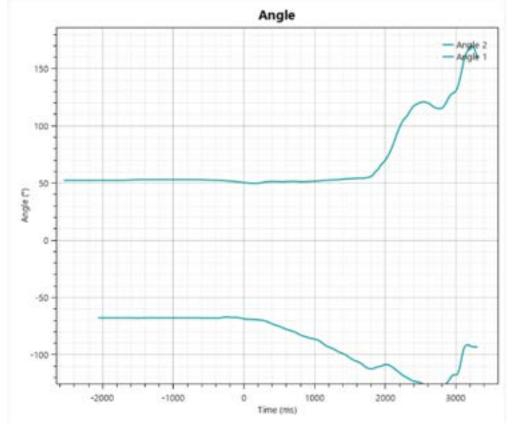
Present: N/A

Goals: Get comfortable with the Kinovea software
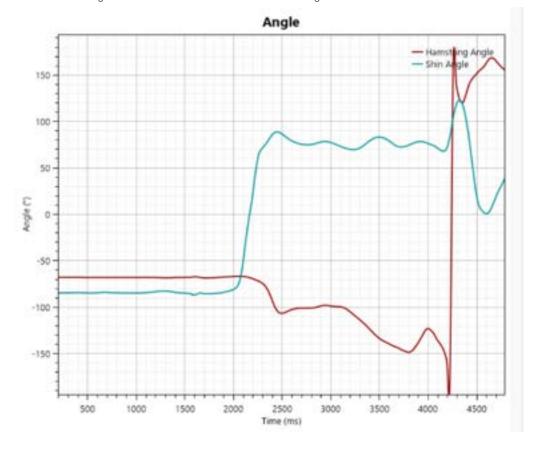
Content:

In order to use Kinovea for testing of the youth athletes, getting used to the software and its capabilities. The main focus of the motion capture will be the angle tracking, so this is what was focused on. Using footage from the 2022 Beijing Olympics, two key angles were able to be graphed and tracked.

These two graphs provide the angle vs time relationships of the angle markers identified in the above shot. This tracking is done over a 5 second period in the video, which is slowed, of the in phase into early flight stage of the jump.

The angle tracking is pretty accurate and only requires slight modifications which can be done frame by frame. The variable changes at the end of the graph data are due to the athlete moving off screen which resulted in incorrect and nonapplicable results that should be ignored.

Conclusions/action items:

Kinovea seems to be the way the project is going for motion capture. The capabilities of the software fit the requirements in the project and the software is free, user friendly, and accurate. Dr. Willie, the BME 315 professor, will be supplying a further lab training guide and Matlab code that can be applied to Kinovea that will automatically process the data.

10/30/2025 - Human Subject Training

Title: Human Subject Training

Date: 10/30/2025

Content by: Caleb White

Present: N/A

Goals: Complete the CITI Human Subject Research Training

Content:

Conclusions/action items:

I now have a solid understanding of human subject research procedures and know the requirements needed for specific cases of research subject consent.

9/10/2025 - BME Career Prep

CALEB WHITE - Sep 10, 2025, 2:06 PM CDT

Title: BME Career Prep

Date: 9/10/2025

Content by: Caleb White

Present: N/A

Goals: Learn the best strategies to approaching the career fair and to getting internships and associated opportunities.

Content:

 Job search tips

- Keep track of what you do; ECS Tracking sheet

- Quality of source matters, Handshake, LinkedIn, Indeed

- Connect before you are a candidate; use your people

- Applying is step 1; follow-up is required (2-3 weeks)

- Think beyond the title; focus on skills, industry, exposure

- It takes time

Resume Tips

- Tailor your resume to the position; quick changes

- Create balance; show a full picture of your experience

- "Flawless" product; ATS proofed resume is do-able

- Technical skills and coursework

- Jobs; organization + location, position title + dates

Cover Letter Tips

- Always based on the job posting

- Custom to each job

- Amplifying your greatest selling points

- Clear and concide support

- Demonstrate employer knowledge

- Address to person

- Recommended vs Required

Outline - Basics

1. Intro: Who are you, applying for, where you found it, and "thesis" statement

2. Paragraph about A

3. Paragraph about B

4. Closing argument

Career Fair Advice for BME

1. Identify your purpose; more than just an intership

2. Looking beyond the obvious

3. Research the employer; feedback from our partners

4. Develop your "value added" statement; why you?

Handshake system is not granular, have to do more than just select BME Internship under medical device category. EX: GE Healthcare is under 'Manufacturing'

It is best to prepare resumes before hand so that you can apply soon after meeting representative.

Conclusions/action items:

CALEB WHITE - Sep 10, 2025, 2:33 PM CDT

Conclusions/action items: The career fair is a really good way to not only pontentially get a job or internship but also to practice the skills and game that is associated with the job application process. The fair can go by very fast and not be taken advantage of, but with the right preparation it can be an amazing starting point. It is important to have an effective and concise resume that is tailored specifically towards a specific employer. It should highlight relevant skills and experiences that the employer and company as a whole is looking for. If anything, the career fair can be used a practice or mock interview type situation where research, preparedness, and professional etiquette are all values and looked for.

9/17/2025 - Leadership

CALEB WHITE - Sep 17, 2025, 2:01 PM CDT

Title: Leadership

Date: 09/17/2025

Content by: Caleb White

Present: N/A

Goals: Learn how to be a leader and what a leader looks like including learning about the different leadership styles.

Content:

Anatomy of a good leader:

Self-awareness, vision, transparent, communication, decision-making, empathy

Leadership can be practiced at a variety of levels:

- Organizational skills

- Leading an actual team

- Practicing Interpersonal

- Personal skills

Self-assessment tools can help you grow your self-awareness & awareness of others

- Myers-Briggs: Personality quiz

- DiSC: Behavior quiz

- Clifton Strengths: identifies areas of talent and potential

Styles of Leadership

- Power model: leadership = power. Take control of the situation, control is important, specific people are born to lead. Includes hierarchy and authority

- Servant: Being in service of others, sharing power, listening and understanding. Empathy, empowering others, shared decision making

- Authentic: Building self-esteem and self-awareness, emotional intelligence, creating authentic relationships. Transparency, genuineness, honesty

Types:

People oriented leader

Process oriented leader

Thought oriented leader

Impact oriented leader

Goal Setting: A goal for the semester is to attempt to be more of a vocal leader. I find myself often being a impact based leader and potentially a thought based leader but practice at more vocal leadership dynamics would be valuable for my own development. Getting opportunities through not only group projects but clubs and other activities is what is required from me as I must attempt to apply myself as best as possible as this is what is necessary for the achievement of these goals.

Conclusions/action items:

A goal for the semester is to attempt to be more of a vocal leader. I find myself often being a impact based leader and potentially a thought based leader but practice at more vocal leadership dynamics would be valuable for my own development. Getting opportunities through not only group projects but clubs and other activities is what is required from me as I must attempt to apply myself as best as possible as this is what is necessary for the achievement of these goals.

9/24/2025 - Mentorship of 200 students

CALEB WHITE - Sep 24, 2025, 3:33 PM CDT

Title: Mentorship of 200 Students

Date: 09/24/2025

Content by: Caleb White

Present: N/A

Goals:

Content:

200 Student Mentorship

- Additional instructional and emotion support

- Gain leadership and communication skills

- Practice active listening

- Been in their shoes so can give advice and guide them where they are unsure

- Also helps with interpersonal skills, study practices, and self-awareness

Could also help with personal self-esteem / confidence

Help with increased patience

Build positive habits

Foster personal growth

Help identify gaps in my own knowledge

Listening effectively

- get rid of distractions

- stop talking

- act like you're interest

- get the main idea

- check for understanding

- react to ideas not person

List of resources

- Importance of documentation

- The 300's are also learning and also navigating the course the best they can

- The semester ramps up very quickly; it is very easy to put the class to the side, so it is necessary to stay on top of everything

Mentor Map

(A picture of the map is linked below)

Conclusions/action items:

This lecture provided an opportunity for all of the BME 300 students to reflect and think about their mentorship of the 200 students thus far, and take this evaluation and make according changes for the rest of the semester. Seeing as only a year ago we were in their shoes, we want to answer any questions and eliminate any doubt that we might have had as 200 students. The mentorship of the project is not solely about helping with the project or taking the lead on deliverables but also about providing a resource for any sort of concern the students may have, extending beyond the content of the course.

CALEB WHITE - Sep 24, 2025, 3:29 PM CDT

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IMG_3872.heic (60.4 kB)

10/01/2025 - Ellen Macarthur Foundation

CALEB WHITE - Oct 01, 2025, 1:45 PM CDT

Title: Ellen Macarthur Foundation

Date: 10/01/2025

Content by: Caleb White

Present: N/A

Goals:

Life cycle assessment -> Circular Thinking, when is it worth it, when it is not worth it

Environmenntal Thinking with life cycle assessment

- Carbon footprint

- raw material extraction

- Disposal / recycling

- manufacturing

Allows for qualitative vs quantitative assessment

Coffee Pot assessment

- Keurig Pods vs Coffee Pot

Speculums

- single use vs metal reusable ones

- use data to see environmental impact

- How much plastic goes into one, how much steel goes into one, combine this with use number, which has the overall greater impact.

- This analysis should include washing materials for the metal ones and then an account for how often these products are actually going to be used, this should contribute to choice.

- Also have to consider the labor associated with washing the metal ones. The cycle and decision making criteria go beyond just the materials or net use.

The cycle of the Medical Device industry

- Based on the idea of a circular economy

- Risk levels including infection risk.

- The Level of medical device (1,2, or 3) determines the life cycle of the device in terms of repeated use and in terms of recyclability.

How do we use tools to engineer a more sustainable world

- Reuseable vs single-use disposable gowns

- Nosocomial infections are the basis of the decision

Content:

Conclusions/action items:

10/08/2025 - Technology Transfer

CALEB WHITE - Oct 08, 2025, 1:55 PM CDT

Title: Technology Transfer

Date: 10/08/2025

Content by: Caleb White

Present: N/A

Goals: Learn about patents, trademarks, and publishing research

Content:

Technology Transfer: Moving research results from campus out into the market. WARF works at this interface to facilitate securing IP rights and commercial licenses.

Four types of IP:

1) Patents

2) Copyrights

3) Trademark

4) Trade Secret

Other WARF IP:

- Biomaterials

- Technique and know how

- Data

Copyrights: Protection for creative works that are expressed in a tangible medium. A wide range of subject matter, including software code

Trademarks: Protection for names, marks, logos, dress, etc. Requires use in commerce, source-identifying function

Trade-Secrets: Can be used to protect anything of value, Protection is good so long as the concept is not generally known.

Patents Generally

- A patent is a property right, granted by a government agency.

- USPTO

- Opposite of trade-secret

- No Global patent

Three types

1) Design (15 year term, limited to ornamental features)

2) Plant (New variety, 20-year term, asexually reproducing)

3) Utility

 - Provisional (1 year placeholder)

- Non-provisional (20 year term)

Issued for the invention of new and useful process, machine, manufacture, or composition of matter. Also includes new and useful improvements,

A quid pro quo with the USPTO and the public

Applicant gets a time limited monopoly on your invention

Often takes 2-5 years to issue after filing

Costs, on average, 30K, mostly attorney fees

90% of patents issued by USPTO

Requirements for patenting:

101 - Eligible: Cannot be a product of nature, abstract idea, or natural phenomenon

102 - Novel: it must be new

103 - Non-Obvious

112 - Enabled and Disabled

IP Considerations:

- Type of IP protection

- Potential breadth and strength of IP protection

- Public disclosure

- Stage of development

Licensing Considerations:

- Applications

- Likelihood of identifying a commercial partner

- Likely return from licensing

WARF receives 400 new innovation disclosures each year

Market Analysis:

- Market status

- Size and type

- Potential licensees

License Negotiation:

- Type and terms

- Consideration

Ongoing:

- Technology development, enforcement, amendment termination

Conclusions/action items:

There is a lot of delineation depending on what is wanted to do. Alot of analyzation and research goes into wanting to public a method

10/15/2025 - Intellectual Property

Title: Intellectual Property

Date: 10/15/2025

Content by: Caleb White

Present: N/A

Goals: Understand the importance of intellectual property for biomedical engineers

Content:

Biomedical engineers create life-changing solutions

IP protection for safety

Building IP knowledge:

- legal career paths for biomedical engineers

Technical advisor: STEM degree (no law degree or patent bar)

Patent agent: STEM degree + patent bar

Patent Examiner: Stem Degree (patent bar eventually)

Patent Attorney: Law degree + patent bar

Patent Litigator: Law degree (STEM degree + patent bar optional)

IP license Attorney: Law degree (STEM degree + patent bar optional)

Tech Transfer Manager: Stem degree preferred (Law degree optional)

Engineer: STEM degree (work with IP lawyers to protect your inventions)

- protecting inventions and ownership

- patent protection, searches and infringement

- Trademark, copyright, and trade secret protection

- Counterfeit products in the biomedical industry

Research: determine if an invention is truly new

Analytical reasoning: claim drafting / infringement analysis

Technical writing: translate complex technical concepts into clear, precise language

Communication: explaining tech to non-experts and patent examiners

Creativity: problem-solving in patens / creating competitive products

Collaboration: cooperate with colleagues and external professionals

Project Managment: manage resources, meet deadlines, and organize tasks

University: Disclose before publishing; university usually owns IP; possible license opportunities

Company: employer typically owns inventions, trademarks, copyrights and other IP; review employee agreements

Startup: you own IP; file early, use NDA's, document development

Disclose internally first

publishing before filing and offer for sale = lost patent rights abroad and possible loss of rights in the US

posters or abstracts can count as public disclosures

first to file system (not first to invent

Patent creates a monopoly / stop others

Two main types:

- utility patents: protect how a product works or is made (20 years)

- Design patents: protect the unique visual appearance of a product

A new patent can infringe on an old patent

Trademark: Words, devices, symbols, or a composite of many things

- also sounds, smells, colors, buildings, package shapes

Distinguishes goods or services from others

Conclusions/action items:

Patent and IP regulation when in industry with medical devices is very important to reserve technology and ensure success of the product and the company as a whole. Proper knowledge is also required because it prevents any illegal discourse from the company.

🟪 10/22/2025 - BME Adivising Post Graduate Plans

CALEB WHITE - Oct 22, 2025, 3:00 PM CDT

Title: BME Advising Post Graduate Plane

Date: 10/22/2025

Content by: Caleb White

Present: N/A

Goals: Learn about the difference between the postgrad options and what requirements they require.

Content:

Build your story

- Have opportunities, get involved whilst you are an undergraduate. Undergraduate is perfect time to get involved.

Tie them together - big picture, who you are, want to go, want to be

Research = Important

Statement and Cover Letters

- NO Legos, NO family death

- Don't be "Will do anything"

- Don't I did this, then that, then that

What to do on Statements and Cover Letter

- General start of what you want to and how your narrow experiences apply to broad interests

- Specific to each position or place to which you apply

Tailer each statement to individual institution or place you are applying

Masters Degree, MS

- stepping stone / change directions / gain depth / expand credentials for future

   - medical school

   - industry

   - further school

Can be used to rewrite story

Need time to prep MCAT or apply for Med Schools

Cannot find fundfeeding

Can fill gaps in resume

Higher level of skills - more lab time with less class time

More experiences - teaching, mentoring, research thesis

Older, more maturity

Doctoral, PhD

- desire to be an independent researcher

- write research grants

- work in academia

- leads projects in industry, startups, and consulting

Three MS options within BME - 24 credits

1) Research

- typically done on way to PhD

2) Accelerated Programs

- Funding (TA Only) stipend only (no tuition remission, $1200/credit)

- Accelerated: course work only, independent study / research is allowed

- Biomedical innovation: Project based, project required (BME Design project continuity)

- Partnership with business school

Exploring opportunities and interests

- MEng

- MS in global health

- MS in other engineering Dept.

- MBA

Similar to advice earlier and for PhD programs later

- Find faculty/labs performing research / work in: your passion area and area that aligns with your industry interests

Medical School

- pre-health advising school

- Special requirements for most medical schools

Conclusions/action items:

It is important to think about postgrad options while in undergrad in order to correctly prepare and align yourself for the future that is coming up. There are numerous different options following the completion of undergrad including med school, master's degree program, PhD, and industry. I currently am thinking about getting a master's degree which would require sufficient research to prove that I can apply book concepts to real world application.

10/29/2025 - Device Regulation

CALEB WHITE - Oct 29, 2025, 2:02 PM CDT

Title: Device Regulation

Date: 10/29/2025

Content by: Caleb White

Present: N/A

Goals: Learn about the certain testing that is required for a specific device

Content:

Device regulation is very different case to case and requires a lot of specific regulatory processes needed. Drugs are mostly similar in regulation because of their similar mechanism and action across different drugs, so regulation procedure is a lot more standardized

3 Classes of Medical Device Regulation

1) Low risk: exceeds limits of exemption -> Clearance to Market Device

2) Moderate / Controlled Risk: 510K Substantially equivalent to predicate, De Novo 510K; no predicate, HDE: probable benefit outweighs risk -> Clearance to Market Device\

 - 510k equivalent -> similar device already exists, predicate available

- 510k De Novo -> No predicate exists, device could become a predicate

- If equivalent doesn't exist, both De Novo and PMA

3) High Risk: Reasonable assurance of safety and efficacy -> Approval to market device

Regulations arise from a bad event or bad result that attempts to further prevent these bad results from occurring. This is why predicate and overall substantial regulations are now in place. To prevent these bad results from occurring in the first place.

Not a lot of market consequence to huge device failures because the stories do not rise to our attention with modern media.

- CPAP and SCS devices

Conclusions/action items:

11/05/2025 - Regulatory Strategy

CALEB WHITE - Nov 05, 2025, 2:12 PM CST

Title: Regulatory Strategy: The Framework Guiding Advanced Therapeutic Product Development

Date: 11/5/2025

Content by: Caleb White

Present: N/A

Goals: Learn the regulatory strategies required to get official clearance for the development and publication of an advanced therapeutic product. Understand the overall structure of FDA, including the framework of laws, regulations, and guidance for advanced therapeutics.

Content:

Prof. Bill Murphy

Regulatory Apparatus for US: FDA, specific regulations for the US

FDA Structure and Advanced Therapeutics:

- Device: Pre-market approval, 510(k), IDE

- Drug (CDER): IND (investigative new drug), NDA (New drug application) Approval of these allows marketing of drug to larger community

- Biologic (CBER): IND, BLA (Biologics License Application)

- Gene Delivery, Genome Editing, Cell Therapy - Therapeutics which are becoming much more prevalent in FDA space. Less common for standard of care and FDA approved in general.

FDA Framework:

- US Laws by congress -> FDA Regulations (on FDA interpretation of laws) -> FDA Guidance (on public interpretation of FDA regulations)

- Ex: Federal Food and Drug Cosmetic Act, Public health service Act, 21st century Cures Act, Coronavirus Aid, relief, and economic security Act

- Development of FDA therapeutics will mostly interface at the FDA guidance level

Dramatic Implications: 351 vs 361

- 361: Product taken from a patient and put back into patient. Homologous use (for the same function). Minimally manipulated. 361 products that are homologous use do not require a lot of regulation, Not tested, commodity, low barrier to entry

- 351: Human cell and tissue-based products that are not homologues, require a full-scale regulations process and require a BLA. Assured potency and assured purity, novel design, high barrier to entry

To determine 351 vs 361: Minimally Manipulated -> Homologous Use -> Combined with another article (-> Sterilizing, preserving or storage agent with no new safety concerns) -> Systemic effect or dependent on metabolic activity of the cells (-> Autologous use or allogenic application) If No for any then 351 (except if followed by (), if both No then 351)

Target Product Profile (TPP)

- product vision that exists within a living device

- essentially a PDS but for specifically a therapeutic device

- subcomponents include Core (indication, patients, efficacy, safety, dose and regimen, route of administration), Clinical Development (clinical study and regulatory study pathway, cost, risk, timelines), CMC [Chemistry Manufacturing Controls] (Product attributes, degradants, purity, biocompatibility, shelf life, stability, pharmaceutical compliance

- Qs: Will patients and prescribers want it, will regulators accept it, will payers reimburse for it, why should I fund it.

When developing 351-regulated CGT: Focus on Nonclinical, quality, clinical, and regulatory considerations

Day 1: Pre-IND, FDA meeting and questions

Quality Management Systems: A system that documents policies, processes, internal rules, procedures, and other records to ensure consistent quality

cGMP - Quality assurance laboratories are very controlled.

Manufacturing Run: Materials/Input, expansion Process/output,System, Project, people, machine, up & down stream process

Career Options within a regulated environment: Chemistry, manufacturing, controls

- Cell characterization, potency assay development, in-process controls, data mining and informatics

Conclusions/action items:

The knowledge of the regulatory pathways are just as important ats the device ideation. It is very knowledgeable to know these things and will allow you to move up the food chain in a company.

📦 11/07/2025 - Tong Distinguished Lecture - Kristin Meyers

CALEB WHITE - Nov 07, 2025, 12:54 PM CST

Title: Building a Career of Impact – Why healthcare needs more engineers

Date: 11/07/2025

Content by: Caleb White

Present: N/A

Goals: Learn about Kristin Meyers path to where she is and take advice from her journey and experiences.

Content:

Run towards the hard problems… they are the ones that change the world

Chapter 1: The Foundation – Solve tangible problems, work hard & add value

- Did 4 internships / co-ops during undergrad

- worked random jobs

- worked 5 years at Medtronic: engineering Marketing / Product Launch Technical Sales

- Harvard MBA

- Skyline Ventures: Investor in healthcare

- Arboretum Ventures: Investor in healthcare startup companies

Chapter 2: Climb the Growth Curve - Combine EQ with IQ to multiple impact and reach

- Aetna: Chief of staff to CEO President, Student Health president, great lakes region: commercial & Medicare

- Unified Women's Healthcare: President and Chief Operating Officer, led OBGYN team, got shut down due to COVID-19

Chapter 3: Build and Transform - Drive system-level impact through innovation and scale

- Hopscotch Health: Founder and CEO advanced primary care for rural communities

- Blue Cross Blue Shield Association: Chief Operating Officer enable access, affordability, outcomes and experience for 1 in 3 Americans

Quadruple Aim: Improved Provider Experience, Improved Patient Outcomes, Lower Cost of Care, Improved Patient Experience

US Healthcare is a broken system because of the cost and need for health care for all. The number of physicians, the medical school processes

What is required to build a better health care system:

- Interoperable data infrastructure

- Human centered design

- aligned incentives and measurement

- Connected care delivery platforms

- Simplified and automated infrastructure

- Systems thinking

- Analytical rigor

- Design and Iteration

- Process optimization

- Reliability and safety

5 Pieces of Advice:

- Work Hard and Build Range; Take on the hardest projects, classes and experiences you can find. Effort and range are your foundation

- Seek Diverse Exposure; Explore different sectors, teams and geographies. Gain perspective and learn how systems connect, not just how parts work

- Choose Your People Wisely; Surround yourself with curious, driven, high-integrity people. They will shape who you become

- Know Your Values & Protect Them; Define what matters most - family/friends, health, career/impact, values - and make decisions that align

- Embrace Challenge & Keep Growing; Run towards hard problems. Growth lives on the edge of discomfort - where big impact starts

Conclusions/action items:

Working hard and attacking hard things with integrity with vigor and intensity are necessary to make the differences in the world that we want to.

🧊 11/12/2025 - IRB

CALEB WHITE - Nov 12, 2025, 2:09 PM CST

Title: IRB

Date: 11/12/2025

Content by: Caleb White

Present: N/A

Goals: Build on the knowledge gained from the

Content:

Alot of human rights violations in history:

- US Publich Heath Service Untrated Syphilus at Tuskegee

- WW2 NAzi prisoner Experiments

- US Public Health Services

Ethical Research Frameworks:

- Nuermberg Code 1947

- Declaration of Helsinki 1964

- National Research Act 1974

    - US response to US public health service untreated Syphilis study at Tuskegee

    - Publication of the Belmont shit

Belmont Report:

- Respect for Persons/Autonomy

- Beneficence

- Justice

Applying the Belmont Principles

- 1991 Department of Health and Human Services 45 CFER

IRB Composition

- Diversity of membership required

- race, gender, cultural backgrounds

- scientific expertise: MD, PhD, MPH, clinicians

- non-scientists: community members, IRB staff

IRB Review Requirements

- UW-Madison requires IRB review of all research involving human subjects, including exempt human subjects' research

Common Rule Criteria

- Risks are relevant and proportionate to the benefits, not necessarily the research is fully safe

- Equitable selection of subjects

- Informed consent

- Privacy and Confidentiality

Device Studies

- FDA regulated research oversight project has a few exceptions to the Common Rule

- The early-stage development of devices is a gray area and need to be evaluated on an individual basis for potential IRB review

HIPAA considerations

Category 2: Research Involving Surveys and Interviews

Category 3: Research Involving Benign Behavioral Interventions

Conclusions/action items:

The IRB sets the standard for biomedical human research standards

`11/19/2025 - Russ Johnson

Title: Russ Johnson

Date: 11/19/2025

Content by: Caleb White

Present: N/A

Goals: Learn about Russ Johnson and his experience in the field, and the advice he has to go with it.

Content:

- **Lecturer:** Dr. Russ Johnson, PhD, with 25 years of experience in medical device development, particularly for operating room (OR) technologies.

- **Focus of Lecture:** How new product development (NPD) works in the medical device industry.

- **Industry Characteristics:**

    - Highly regulated, resource-intensive, and expensive.

    - Clinical studies can cost millions of dollars.

    - Speed-to-market efficiency is critical, creating high competition between companies.

- **Types of NPD Projects:**

    - **Line extensions:** Small modifications or variations of existing products.

    - **Product improvements:** Enhancements or upgrades to existing devices.

    - **New-to-company products:** Innovations that are new to the company but already exist in the market.

    - **New-to-world products:** Entirely novel products with no prior existence in the market.

- **Stage-Gate Process:** Structured phases to ensure only viable ideas advance.

    - **Stage 0: Ideation** – Generate approximately 100 ideas through brainstorming.

    - **Stage 1: Exploration** – Narrow ideas down to 8–10; conduct secondary business research and feasibility assessments.

    - **Stage 2: Concept Development** – Refine concepts to 3–5 ideas; continue internal and customer discussions to evaluate potential value and risks.

    - **Stage 3: Design Development** – Begin actual engineering, prototyping, and detailed product development if prior stages approve.

    - **Stage 4: Design Confirmation** – Testing and verification of the design to ensure it meets performance and regulatory standards.

- **Key Takeaways:**

    - Successful NPD requires balancing **innovation, regulatory compliance, cost, and speed to market**.

    - Collaboration across multidisciplinary teams is essential.

    - A structured stage-gate approach helps manage risk and focus resources on the most promising ideas.

Conclusions/action items:

Russ Johnson, taught how new product development works in the industry, including a stepwise checklist of things to make sure the device ideation is viable.

09/11/2025- Research on lift to drag ratio of ski jumper

PRESLEY STELLFLUE - Sep 11, 2025, 10:50 AM CDT

Title: Research on biomechanics of ski jumper

Date: 09/11/2025

Content by: Presley Stellflue

Goals: To learn about the biomechanics of a ski jumper to gain background knowledge needed for our meeting with our client as well as initial ideas for the design.

Search Term: Physiology of Ski Jumper

Citation: Kim W, Lee H, Lee J, Jung D, Choi H. Flow over a ski jumper in flight: Prediction of the aerodynamic force and flight posture with higher lift-to-drag ratio. J Biomech. 2019 May 24;89:78-84. doi: 10.1016/j.jbiomech.2019.04.022. Epub 2019 Apr 19. PMID: 31043228.

Link: **https://pubmed.ncbi.nlm.nih.gov/31043228/**

Content: There are scanners used on professional ski jumpers to detect their lift to drag ratio on their jump. there are two posture models, the legs and skis are the larger parts of the body with higher lift to drag ratio on the skis and upper body and lower ratios on the legs. One posture ratio has a higher lift to drag ratio percentage than the other.

Conclusions/action items: There are multiple factors to take into account when analyzing the effectiveness and safety of a jump including the ratio of body proportions and the angle that the jump occurs at.

09/11/2025 Research on Biomechanics of Ski jumpers

PRESLEY STELLFLUE - Sep 11, 2025, 11:04 AM CDT

Title: Research on Biomechanics of Ski jumpers

Date: 09/11/2025

Content by: Presley Stellflue

Goals: To learn about the biomechanics of a ski jumper to gain background knowledge needed for our meeting with our client as well as initial ideas for the design.

Search Term: postural balance and physiology

Citation: Schwameder H. Biomechanics research in ski jumping, 1991-2006. Sports Biomech. 2008 Jan;7(1):114-36. doi: 10.1080/14763140701687560. PMID: 18341140.

Link: **https://pubmed.ncbi.nlm.nih.gov/18341140/**

Content:

Conclusions/action items:

10/24/25 Ski jumping trainer for Nordic ski team

PRESLEY STELLFLUE - Oct 24, 2025, 12:55 PM CDT

Title: Ski jumping trainer for Nordic ski team

Date: 10/24/25

Content by: presley

Goals: to see what others have done to design a ski jumping trainer so we can benefit of what works and what might not have worked for this project.

Search Term: ski jumping trainer

Citation:

Rasdal V, Moen F, Sandbakk Ø. The Long-Term Development of Training, Technical, and Physiological Characteristics of an Olympic Champion in Nordic Combined. Front Physiol. 2018 Jul 13;9:931. doi: 10.3389/fphys.2018.00931. PMID: 30061843; PMCID: PMC6055063.

Link: https://pmc.ncbi.nlm.nih.gov/articles/PMC10561863/

Content: The Nordic ski team has developed a system for younger skiers to learn from the skills and form of older or more experienced skiers. They use a collection of angles and forces that produce the "best" scoring jump from judges during competitions in the sport.

Conclusions/action items: We will be using the angles and forces as a guideline for what the ideal jump would be

10/18/25 Accelorometer research

PRESLEY STELLFLUE - Oct 17, 2025, 12:41 PM CDT

Title: Acceloromteres

Date: 10 /18/25

Content by: Presley

Goals: to become comfortable and familiar with the workings of an accelerometer and the code we will use to design the one used in our project.

Search Term: Acceloromter code for arduino

Citation:

Z. Cheng, Y. Li and R. West, "Demo abstract: A multithreaded arduino system for embedded computing," 21st IEEE Real-Time and Embedded Technology and Applications Symposium, Seattle, WA, USA, 2015, pp. 332-332, doi: 10.1109/RTAS.2015.7108460. keywords: {Real-time systems;Computer architecture;Robots;Program processors;Linux;Standards;Operating systems},

Link: https://ieeexplore.ieee.org/document/7108460

Content: This article explains the basics and uses of Arduino. Arduino is a hardware and software platform that can be applied to various projects in computer science and electrical engineering.

Conclusions/action items: This will be important so that I can become familiar with the code and understand the reasons why it will help us develop our project into a tool for skiing.

10/24/25 Force plate ressearch

PRESLEY STELLFLUE - Oct 24, 2025, 12:46 PM CDT

Title: Force plates research

Date: 10/24/25

Content by: Presley Stellflue

Goals: to gain more reaseach in the feild of force plates so that i can understand what are the most important things to consider when we are b

Search Term: Force plates for medical research

Citation: Robles-Palazón FJ, Comfort P, Ripley NJ, Herrington L, Bramah C, McMahon JJ. Force plate methodologies applied to injury profiling and rehabilitation in sport: A scoping review protocol. PLoS One. 2023 Oct 9;18(10):e0292487. doi: 10.1371/journal.pone.0292487. PMID: 37812631; PMCID: PMC10561863.

Link: **https://pmc.ncbi.nlm.nih.gov/articles/PMC10561863/**

Content: This is an article about force plates used for medical research regarding injuries and rehabilitation. The force plates are used for many different purposes, such as finding risk of injury, speed of recovery, and strength/balance.

Conclusions/action items: This information is useful to use because we know the scope of the design we are working with, and by knowing the ways that it can be used on a patient relates to the way we approach solving how to increase the quality of our application.

11/19/25 Force plate ressearch

PRESLEY STELLFLUE - Nov 19, 2025, 12:45 PM CST

Title: Force plates research and how to make them accurate in weight recorded

Date: 10/24/25

Content by: Presley Stellflue

Goals: to gain more reaseach in the feild of force plates so that i can understand what are the most important things to consider when we are b

Search Term: The method of fundamental solutions for plate bending under arbitrary distributed lateral forces on partial areas

Citation: Ehsan Samandizade, Mohammad-Rahim Hematiyan,The method of fundamental solutions for plate bending under arbitrary distributed lateral forces on partial areas,Engineering Analysis with Boundary Elements,Volume 181,2025,106530,ISSN 0955-7997,https://doi.org/10.1016/j.enganabound.2025.106530.

Link:

https://doi.org/10.1016/j.enganabound.2025.106530.

Content: This article provides knowledge on the forces applied in different lateral areas of the force plate.

Conclusions/action items: This information is useful because by knowing where the amounts of force in the plate should be and how to calibrate the plates so that the force measured represents a real-life measurement of weight that is proportional to that of a scale. We need to make sure that the weight recorded is something measurable and comparable.

9/26/25 Accelerometers (IMUS)

Title: 2/26/25 Accelerometers IMUS

Date: 9/26/25

Content by: Presley

Present: Presley
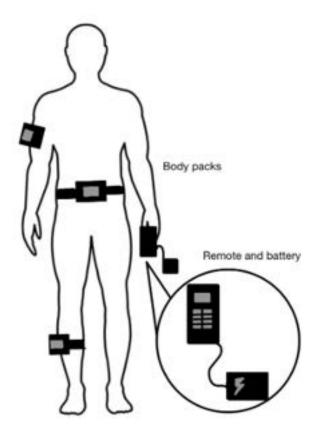
Goals: To make a realistic idea for a final deliverable, this is our first draft.

Content:

Conclusions/action items:

Body packs

Remote and battery

9/26/25 Force plates and Motion Capture

Title: 2/26/25 Force plates and Motion Capture
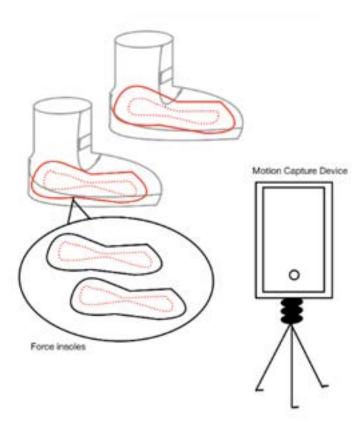
Date: 9/26/25

Content by: Presley

Present: Presley

Goals: To make a realistic idea for one of our final deliverables, this is our first draft.

Content:

Conclusions/action items:

9/26/25 EMG sensors

Title: 2/26/25 EMG sensors
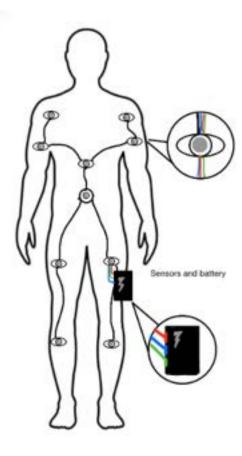
Date: 9/26/25

Content by: Presley

Present: Presley

Goals: To make a realistic idea for one of our final deliverables, this is our first draft.

Content:

Conclusions/action items:

Sensors and battery

11/19/25 velcro strap for microcontroller

PRESLEY STELLFLUE - Nov 19, 2025, 12:28 PM CST

Title: Velcro Staps for microcontroller

Date: 11/19/25

Content by: Presley

Present: Presley

Goals: To find Velcro straps that will fit in the microcontroller compartment that we 3d printed at Wednt Commons.

Content: the velcro strap will be threaded through the arms of the microcontroller holder and will be wrapped around the ankle of the boot, similar to a barcelet strap.

Conclusions/action items: find a velcro strap that will properly attach to the boot and be removable between the wears of the other athletes.

![icon] **9/26/2025 biosafety training**

PRESLEY STELLFLUE - Sep 26, 2025, 1:00 PM CDT

Title: Biosafety Training

Date: 9/26/25

Content by: Presley

Present: Presley

Goals: to complete my biosafety training and be verified to work in related labs such as biomedical training labs and other chemical wet labs.

Content: Learned basic rules of the lab and what the main safety hazards are, what to avoid, and how to properly access and use the labs available.

UNIVERSITY OF WISCONSIN-MADISON

This certifies that Presley Stellflue has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2024-2025	9/13/2025	9/13/2050
Chemical Safety: The OSHA Lab Standard	Final Quiz	9/13/2025	

Data Last Imported: 09/26/2025 12:54 PM

Conclusions/action items:

9/26/2025 chemical training

PRESLEY STELLFLUE - Sep 26, 2025, 1:01 PM CDT

UNIVERSITY OF WISCONSIN-MADISON

This certifies that Presley Stellflue has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2024-2025	9/13/2025	9/13/2050
Chemical Safety: The OSHA Lab Standard	Final Quiz	9/13/2025	

Data Last Imported: 09/26/2025 12:54 PM

Title: Biosafety Training

Date: 9/26/25

Content by: Presley

Present: Presley

Goals: to complete my biosafety training and be verified to work in related labs such as biomedical training labs and other chemical wet labs.

Content: Learned basic rules of the lab and what the main safety hazards are, what to avoid, and how to properly access and use the labs available.

20/25/10/31 Intro to machining

PRESLEY STELLFLUE - Dec 04, 2025, 9:11 AM CST

Title: Intro to machining

Date: 10/31/25

Content by: Presley

Present:

Goals: Gain training documentation for Introduction to Machining and learn how to use the lathe and mill for project purposes properly.

Content:

Conclusions/action items:

10/1/25 Dr. Bartels 2nd Meeting

PRESLEY STELLFLUE - Oct 01, 2025, 1:05 PM CDT

Title: Dr Bartels 2nd

Date: 10/1/25

Content by: Presley

Present: Whole group

Goals: to get more insight into how to organize our project

Content:

> **- get some sort of model**
>
> **- with the point kinetics model, analyze**
>
> **-The velocity of launch and launch angle could be helpful**
>
> **-estimate parameters on the motion capture if it can go fast enough.**

Conclusions/action items:

Look at Steve Bunton, professor, mechanical engineering at another university

11/3/2025 - Dr. Bartels Fifth Meeting

PRESLEY STELLFLUE - Nov 19, 2025, 12:30 PM CST

Title: Bartels' Fourth Meeting

Date: 10/17/2025

Content by: Presley

Present: Matthew and Sarah, and Presley

Goals: Get advice about the ski hill closing issue.

Content:

Since the hill closing is out of our control, using videos as data is also okay.

Another option he suggested was to just use the force plates to measure our forces when using the plates, and then validating the weight with a scale or something.

Use the videos for primary collection, and then, in the final design, highlight the issues we faced.

Conclusions/action items:

Collect any more videos we would be able to and then go from there by using ourselves for testing the force plates.

2025/11/03 Tong lecture Kristen Myers

PRESLEY STELLFLUE - Nov 07, 2025, 12:44 PM CST

Title: 2025/11/07 Tong lecture Kristen Myers

Date: 2025/11/07

Content by: Presley Stellflue

Present: Presley Stellflue

Goals: To learn more about the pathways to becoming a successful engineer and tips in entrepreneurship

Content:

She started with multiple jobs and was very well-rounded. She swam, had an essay-writing job, babysat, and did many other things. Later in her career, she started working at startups or smaller biomedical engineering companies.

Soon she began at CVS/Aetna and was leading Aetna, which was a billion-dollar company in need of help, and was leading 300 people through the company's rough time. She was the chief of staff to ceo here. Then, later, she started at United Women's Healthcare.

She pointed out how the healthcare system needs to be improved so that people have a positive experience in it like they would in Apple. Her main goal is to improve the overall success and experience of healthcare.

How much do we spend on healthcare in the us? ($$ adn % of gdp)

- - 18% which is 18 billion dollars.
- lower life expectancy
- faculty burnout
- skipping care because they can't afford it
- 1.2 trillion dollars in waste

underlying challenges:

- misaligned incentives
- data silos and legacy it
- inequities:(10-15 year gap between zip codes)

How to build a better healthcare future:

- integrated system
  - home
  - blue+green
  - critical hospital care
  - asc
  - flex zone
  - logistics hub
- interoperable data infrastructure
  - seamless exchange of clinical, claims, providers, and patients
- human-centered design
  - care built around people, not processes, intuitive, empathetic
- aligned incentives and measurements,
  - Everyone is rewarded for outcomes
  - preformatce is transparent and known to all
- connected care delivery platforms
  - integration of virtual in-person home and community care
  - real-time data integration.

!. Work hard and build range:

- Take on the hardest classes and experiences that you can find. Effort and range are your foundation

- be in the office versus online
- Getting range means to like wear many hats, live in different places with different jobs, and gain experience
- She worked across the country and for pacemakers and for biomechanics,s and other things and lived in Silicon Valley.

2. Seek diverse exposure

- worked as a personal trainer while working at Medtronic
- Find what you like

3. Choose your people wisely

- The first five people you spend the most time with define you

4. Know your values and protect them

- define what matters most
- What things do you value the most
- sleep
- have people that offset the struggles you have

5. Embrace challenge and keep growing

- Run towards hard problems
- growth lives on the edge of discomfort

Conclusions/action items:

operate from curiosity and use your fears to help you make it to a place where you feel successful. Take care of yourself and you will be fine, and if you work hard, it will not go wrong.

12/4/25 Standard for Ankle ROM in Ski Boot

PRESLEY STELLFLUE - Dec 04, 2025, 9:34 AM CST

Title: Standard for Ankle ROM in Ski Boot

Date: 12/4/25

Content by: Presley Stellflue

Goals: To find standards on ski boot devices and other ski-related athletic devices that connect to our design.

Search Term: ski

Citation:

L. Bortolan, A. Savoldelli, F. Schena and B. Pellegrini, "Standardized procedure to measure ankle range of motion of ski mountaineering boots," 2022 IEEE International Workshop on Sport, Technology and Research (STAR), Trento - Cavalese, Italy, 2022, pp. 189-194, doi: 10.1109/STAR53492.2022.9859713. keywords: {Legged locomotion;Accelerometers;Warranties;Torque;Three-dimensional displays;Snow;Motion measurement;standard;ski-boots;methodology;ski mountaineering;biomechanics},

Link:

https://compass.astm.org/content-access?contentCode=ASTM%7CF3728-24%7Cen-US

Content:

The study measured how ski boots limit ankle movement using lab and slope tests. Boot type and slope change ankle angles and forward force. Shows how boots affect jump posture. Gives data to improve boot performance and safety.

Conclusions/action items:

Boot type and slope affect ankle movement and forces. Heel boot force stays the same; forward/ball of the foot force changes.

Action Items:

Use this data to pick boots that allow better jump posture. Adjust training or technique based on ankle range of motion. Consider boot design for safer, more efficient landings.

12/4/25 Kinovea research

PRESLEY STELLFLUE - Dec 04, 2025, 9:20 AM CST

Title: Kinovea research

Date: 12/4/25

Content by: Presley

Goals: To understand how to use Kinovea to our team's benefit while evaluating ski jumper video footage using software.

Search Term: Kinovea

Citation:

Muhammed Rashid, Sherin Siby, Jerin Mathew, Sayed Asif Basha, Kavitha Raja, Comparison of sway meter and Kinovea software as a tool of measurement for the sway parameters during quiet standing: An observational study, Journal of Bodywork and Movement Therapies, Volume 35, 2023,Pages 337-341,ISSN 1360-8592,https://doi.org/10.1016/j.jbmt.2023.04.082. (https://www.sciencedirect.com/science/article/pii/S1360859223000979)

Link: https://www.sciencedirect.com/science/article/abs/pii/S1360859223000979

Content: This study examined whether Kinovea can accurately measure postural sway compared to a traditional sway meter. The researchers found that Kinovea produced highly reliable sway measurements across different surfaces, showing that it can serve as an affordable and practical tool for evaluating balance.

Conclusions/action items:

These findings help your ski jump project because they show that Kinovea can reliably measure movement and sway using just video, making it a cost-effective tool for analyzing jump technique. This supports using Kinovea to track knee, ankle, and body angles during takeoff and landing without needing expensive motion-capture equipment.

9/10/2025 - Physiology of alpine skiing

Title: Physiology of alpine skiing

Date: 9/10/2025

Content by: Matthew Niemuth

Goals: Understand more about how the biomechanics and physiology of skiing can help improve ones skiing technique.

Search Term: Biology and Physiology of skiing

Citation:

Link: https://www.researchgate.net/publication/24247534_Physiology_of_alpine_skiing

Content:

Here are a few points in the article that shows how understanding the biomechanics and physiology directly relates to improving ones skiing technique.

1. Biomechanics and Technique

- Research comparing disciplines (SL, GS, DH) shows difference in joint angles, turn cycles, and force demands.

    - for example, GS involves deeper knee/hip angles and higher blood occlusion, while SL relies on quicker, cyclical turns with less isometric load

    - these biomechanical difference affect posture, muscle loading, and therefore the technique skiers must adopt

 - Elite vs novice skiers:

    - elite skiers use more aggressive, dynamic movement patterns compared to novices' static style

    - this essentially means that better biomechanics = more efficient technique that allows higer forces with less wasted energy

2. Physiology and Technique
- Energy system contributions (65% anaerobic, 35% aerobic)

    - poor lactate tolerance or limited anaerobic power may cause technique to break down under fatigue
- Muscle physiology

    - skiing relies heavily on eccentric muscle contractions, which create fatigue differently than concentric sports

    - knowing this influences training and teaches skiers to manage force application during turns, keeping technique sharp late in a race

- Muscle fiber type

    - elite skiers tend to have more slow-twitch fibers, which help them tolerate ischemia/hypoxia and sustain posture/technique under strain

    - training that develops endurance and recovery helps maintain technical precision throughout long race days

3. Environmental Physiology and Technique

- cold and altitude increase physiological strain (glycogen depletion, hypoxia, high HR), which can cause technique breakdown if not anticipated

- athletes who train with these stressors in mind are better able to maintain efficient technique in real race conditions

Conclusions/action items:

Overall takeaways about how understanding physiology of skiing can help design better training

- Designing training that targets the demands of turns, forces, and energy use

- helping athletes maintain technical precision under fatigue, altitude, and cold

- understanding why elite skiers move differently from novices, and how to model training to replicate those movement patterns

9/16/2025 - Competing Design 1

Matthew Niemuth - Sep 16, 2025, 10:18 PM CDT

Title: Competing Design 1

Date: 9/16/2025

Content by: Matthew Niemuth

Goals: Research a competing design

Search Term: Motion Capture Systems

Citation:

[1]

H. Brock, Y. Ohgi, and K. Seo, "Development of an Automated Motion Evaluation System from Wearable Sensor Devices for Ski Jumping," *Procedia Engineering*, vol. 147, pp. 694–699, Jan. 2016, doi: 10.1016/j.proeng.2016.06.248.

Link: 10.1016/j.proeng.2016.06.248.

Content:

a. Automated Motion Evaluation System from Wearable Sensor Devices for Ski Jumping [1]

    i. Researchers developed a machine learning-based system using inertial sensors to automatically evaluate ski jumping performance, capturing full-body motion data from junior athletes and comparing it to style scores from expert judges to train and test the model.

    ii. The system segments jumps into key phases, analyzes kinematic features, and detects style faults in accordance with official scoring rules, showing strong alignment with human judging and offering potential for more objective, mobile performance evaluation in jury-based sports.

    iii. A multi-step data processing pipeline was developed to extract accurate kinematic motion data from inertial sensors, including sensor-bone alignment, orientation estimation, magnetic disturbance compensation, and joint position calculation, enabling reliable segmentation of ski jumps into key phases like flight and landing.

    iv. Key motion features—both technical (e.g., ski angles, joint positions) and aesthetic (e.g., stability, leg extension)—were extracted and used in a machine learning pipeline with Dynamic Time Warping to compare jumps against reference patterns, achieving high precision and recall (70–85%) in detecting style errors relative to human judge scores.

Conclusions/action items: The Automated Motion Evaluation System demonstrates the feasibility of using wearable inertial sensors and machine learning to objectively assess ski jumping performance. By aligning closely with expert judge scores and accurately identifying style faults, the system offers a reliable, mobile alternative for evaluating athletes in jury-based sports. This approach not only enhances training feedback for junior athletes but also paves the way for broader applications in automated sports judging.

9/16/2025 - Competing Design 2

Matthew Niemuth - Sep 16, 2025, 10:24 PM CDT

Title: Competing Design 2

Date: 9/16/2025

Content by: Matthew Niemuth

Goals: Research Competing Designs

Search Term: Ski Jump Motion Capture

Citation:

"Capturing Ski Jumping Biomechanics with Markerless Motion Capture | Theia Markerless." Accessed: Sept. 16, 2025. [Online]. Available: https://www.theiamarkerless.com/blog/ski-jumping-biomechanics-markerless-motion-capture

Link: https://www.theiamarkerless.com/blog/ski-jumping-biomechanics-markerless-motion-capture

Content:

a. Theia Markerless Motion Capture Device [2]

    i. Uses 10 SONY RX02 cameras to collect data sets of ski jumping movements in a ski jumping stadium

    ii. Uses data collected from cameras to offer insight into performances, technique, and aerodynamics

    iii. Analyzes the joint angles of the hip, knee and trunk movement across the takeoff phase, aerodynamic profiles in airflow and lift/drag during flight phase, and real-world technique to give performance insights

    iv. User-friendly "ANALYZE" function after calibration to accelerate data processing

Conclusions/action items:

The Theia Markerless Motion Capture Device provides a non-invasive, camera-based solution for analyzing ski jumping technique in real-world environments. By capturing detailed joint kinematics and aerodynamic profiles during critical phases of the jump, it delivers valuable insights into performance and technique. Its streamlined "ANALYZE" function enhances usability, making advanced biomechanical analysis more accessible for coaches and athletes.

9/26/2025 - Top three force plate metrics and what are they telling us: A view of 6 experts

Matthew Niemuth - Sep 26, 2025, 4:47 PM CDT

Title: Top three force plate metrics and what are they telling us: A view of 6 experts

Date: 9/26/2025

Content by: Matthew Niemuth

Goals: Learn about what type of metrics force plates measure, how they do it, and why these metrics are important

Search Term: What metrics do force plates measure?

Citation:

[1] "Top three force plate metrics and what are they telling us: A view of 6 experts," Sportsmith. Accessed: Sept. 26, 2025. [Online]. Available: https://www.sportsmith.co/articles/top-three-force-plate-metrics-and-what-are-they-telling-us-a-view-of-6-experts/

Link: https://www.sportsmith.co/articles/top-three-force-plate-metrics-and-what-are-they-telling-us-a-view-of-6-experts/

Content:

Force Plate Metrics that are measured:
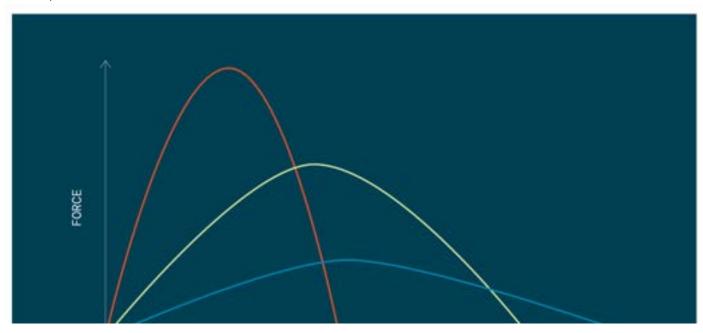
1. Jump Height (via Impulse or Takeoff Velocity)

- What is it: Displacement of the center of mass during a countermovement jump (CMJ)

- How it's measure: Derived from vertical takeoff velocity (from force-time curve).

- Why it matters: Global indicator of athleticism, easy for athletes to understand, but doesn't show how the jump was achieved.

2. Flight Time: Contraction Time (FT:CT) or Velocity Index

- What it is: Ratio of time in the air vs. time spent generating force
- How it's measure: Force plate tracks time from movement of takeoff to the landing
- Why it matters: Shows efficiency of the stretch-shortening cycle (SSC). High ratio = athlete jumped high and fast.

3. Net Eccentric Deceleration Impulse
- What it is: total "breaking force" used to stop downward motion before pushing up.
- How it's measured: Area under the negative (eccentric part of the force-time curve
- Why it matters: reveals braking strategy - "slamming on the brakes" vs. gradual deceleration. Critical for injury risk, rehab, and change-of-direction sports
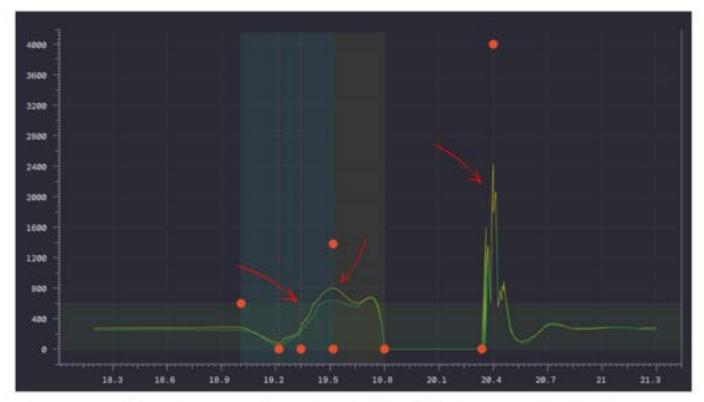
Figure 2. CMJ force-time curve for a typical athlete following ACLR showing between-limb differences in eccentric deceleration impulse (first arrow) and concentric impulse second arrow. Green = injured limb.

4. Propulsive (Concentric) Impulse/Con100

- What it is: Force applied during the upward (positive) phase; Con100 = force early in the phase

- How it's measure: Area under the concentric part of the force-time curve.

- Why it matters: Tells us how explosively force is produced. Con100 differentiates elite from sub-elite athletes, and tracks fatigue/adaptation.

5. Asymmetry (Impulse or Force Asymmetry)

- What it is: Difference between left and right limbs during eccentric and/or concentric phases.

- How it's measured: Dual plates compare limb contributions as % difference

- Why it matters Essential for rehab (e.g., ACL recovery), load monitoring, and injury risk screening.

Conclusions/action items:

This article highlights that force plates go far beyond simply measuring jump height, offering detailed insights into how athletes produce and control force through the stretch-shortening cycle. By analyzing metrics such as eccentric deceleration impulse, concentric impulse, flight time to contraction time ratios, and asymmetry, practitioners can profile performance, monitor fatigue, and track rehabilitation progress with precision. Ultimately, force plates are valuable because they reveal *how* an athlete moves, not just *what* the outcome looks like, making them essential tools in performance and injury management.

9/27/2025 - Force Plate insole options

Matthew Niemuth - Sep 27, 2025, 1:40 PM CDT

Title: Force Plate Insole Options

Date: 9/27/2025

Content by: Matthew Niemuth

Goals: Compare different force insoles to see which ones best fit our budget and help us gather ski jump metric data.

Search Term: Force Plate Insoles

Content:

Force Plate Insole ---------------------------->	DIY FSR Insole (4-sensor or small FSR array)	Novel loadsol (entry/basic)	Moticon OpenGo
Feature			
Direct Measurement	Pressure/resistance change from FSRs; you read voltage and map to force after calibration (not a calibrated research sensor out of the box)	Direct plantar normal force measured by a single flexible sensor covering the plantar surface (loadsol measures total plantar force).	Measures **pressure distribution + total load** (insole processes to give load & COP). Integrated sensor insole (pressure sensels + firmware).
Typical sampling (temporal resolution)	Depends on your ADC / MCU — easy to get **100–1,000+ Hz** with simple electronics, but real performance/consistency depends on wiring and ADC. (practical builds often use 200–1k Hz).	loadsol basic variants are sold in lower-cost configs; Novel offers Pro up to **200 Hz** (entry models lower). Use purchase/spec pages to pick model.	OpenGo is a research/commercial product with selectable sampling; pricelist and product docs / validation papers show **research-oriented rates (commonly up to 100 Hz in pricelist; some product lines / firmware permit higher sample rates for science use)** — see Moticon specs.
Spatial resolution	Very low (you choose number/placement of FSRs — typical DIY = 1–8 sensors). Good for gross total/region force only.	Low — single flexible sensor provides total plantar force (some variants / add-ons give zonal info). Not a high-resolution pressure map.	Medium — full insole sensel matrix (pressure distribution + COP available). Much higher spatial detail than loadsol single-sensor approach.
Validation/accuracy	Highly variable. Cheap FSRs are sufficient for prototyping and relative comparisons but require calibration and have known issues (nonlinear response, drift, hysteresis). Not research-grade without careful validation.	Research / clinical device with validation history; loadsol is used in many studies comparing it against force plates for peak force/impulse metrics. Better out-of-box validity for total vertical force.	Commercial research device with peer-review validations (OpenGo has several validation studies vs Pedar/force plates). Good for both total load and spatial metrics.
Battery/autonomy & field use	Depends on your build (small LiPo + MCU can run hours). Very lightweight and cheap but less polished (wiring, data logging, waterproofing are DIY tasks).	Designed for field use, wireless, smartphone app — vendor markets it for remote/clinical use; robust and easy to deploy.	Designed for real field/lab use, wireless, desktop/mobile software, enterprise features (longer product support). Pricelist and downloads available.
Best for (when to choose)	Lowest cost rapid prototyping, student projects, initial feasibility/bench validation vs force plate. If you have time to calibrate and validate vs a plate, this is the cheapest route.	If you want an inexpensive commercial solution that measures total jump force reliably with minimal zones and low purchase overhead — good balance of cost and validated force measures.	If you need the insole to produce validated load + pressure maps and you can afford mid-range commercial hardware — OpenGo gives jump reports and validated outputs for research.

Typical limitations	Durability, repeatability, sensor nonlinearity, need for custom electronics & calibration; time cost to validate vs force plate. Not plug-and-play.	Limited spatial detail (single sensor) — can miss local pressure distribution. Pick Pro /200 Hz if very high-frequency resolution is required for your jump protocol.	More expensive; sensor replacement and software licenses add recurring costs; may be overkill if you only need peak vertical GRF and want the cheapest option.
Cost	$50 - $300 for sensors + microcontroller + wiring/enclosure (parts only)	Around $1,000 for entry prices. Higher for Pro/multi-zone.	$1,500 to $2,000

What Metric data is collected for each?

DIY FSR insole (few sensors)

- Vertical (normal) force / load (via FSR sensors calibrated)
- Ground Reaction Force (GRF) estimates (especially vertical component)
- Center of Pressure (CoP) via combining multiple FSRs
- Pressure / force at specific zones (heel, metatarsals, toes, etc.)
- Possibly timing metrics: stance vs flight, contact time (if you have good timestamps)

Novel loadsol (basic/entry/minimal zones)

- Total plantar normal force (i.e. vertical GRF)
- Peak force (impact / landing)
- Impulse (force-time integral over stance)
- Loading rate (rise of force / time to peak)
- Contact time / stance time vs flight time (if jump)
- Limb symmetry indices (comparing left vs right)
- Possibly dividing load into a few zones: some layouts allow separate forefoot vs heel (or more) zones (a minimal zoning)

Moticon OpenGo

- Total load (force) data over time (vertical GRF)
- Plantar pressure distribution
- Temporal & spatial gait metrics: step time, stance/flight, cadence, etc.
- Motion / load sync; left/right timing synchronization; motion events
- Real-time & recorded data; ability to export raw data
- Auto zeroing / drift correction; some biofeedback / reports
- Possibly jump metrics (peak force, impact, but depends on sampling layout) — though the max sample rate (10–100 Hz) may limit very fast transients.

Citation:

[1] "loadsol®," novel USA. Accessed: Sept. 27, 2025. [Online]. Available: https://www.novelusa.com/index.php

[2] "OpenGo Sensor Insoles - Wireless pressure, force & motion sensing," Moticon. Accessed: Sept. 27, 2025. [Online]. Available: https://moticon.com/opengo/sensor-insoles

[3] "A DIY Smart Insole to Check Your Pressure Distribution," Hackster.io. Accessed: Sept. 27, 2025. [Online]. Available: https://www.hackster.io/Juliette/a-diy-smart-insole-to-check-your-pressure-distribution-a5ceae

Conclusions/action items: The entry/basic Novel loadsol fits our budget the best and will allow us to measure the jump force metric we need.

11/13/2025 - Microcontroller storage Unit Initial Design

<div align="right">Matthew Niemuth - Dec 03, 2025, 7:52 PM CST</div>

Title: Microcontroller storage Unit Initial Design

Date: 11/13/2025

Content by: Matthew

Present: Matthew, Kenneth, and Presley

Goals: Design a Microcontroller storage unit
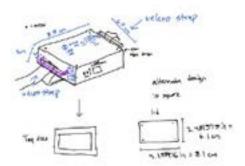
Content:

PDF of design below.

Conclusions/action items:

Here is our initial design for the microcontroller storage unit. It will be attached to the back of the boot via Velcro strap and hold our microcontroller.

<div align="right">Matthew Niemuth - Dec 03, 2025, 7:54 PM CST</div>

[Download](#)

Microcontroller_Storage_Unit_Design.pdf (171 kB)

11/20/2025 - Final Microcontroller Unit CAD Design

Matthew Niemuth - Dec 03, 2025, 8:10 PM CST

Title: Final Microcontroller CAD Design

Date: 11/20/2025

Content by: Matthew

Present: n/a

Goals: Design our updated design of our microcontroller box on CAD.

Content:

PDF below. + how to create it in OnShape

Microcontroller Storage Fabrication Steps:

1. Open Onshape and create a new document to make part

2. Create a new sketch on the Top plane and draw a 3.346 inches by 2.559 inches rectangle.

3. Extrude rectangle up 1.279 inches.

4. Create a new sketch on the top plane of the box and draw a center point rectangle 2.756 inches by 1.969 inches.

5. Extrude down into the box 1.1811 inches.

6. Create a new sketch on the right face of the box and draw a center point rectangle 1.969 inches by 0.394 inches.

7. Extrude rectangle from prior step 0.394 inches and duplicate it on the left side of the box.

8. Once both handles are extruded, create a new sketch and draw a rectangle from where the handle connects to the box to 0.275 inches across the handle. Set the length of this rectangle to 1.6 inches. Repeat on the other handle.

9. Extrude through the rectangles in the previous step to create the handles.

10. Create a new sketch on the front face of the box. Sketch a rectangle on the center of that face for the button 0.416 inches by 0.228 inches. Sketch another rectangle for the wire hole at the center of the right half of the front face 0.591 inches by 0.295 inches.

11. Extrude through the two rectangles in the previous step all the way through to create the button hole and the wire hole.

12. Filet all the edges of the box with a 0.079 inch radius.

13. Face blend the interior faces of the handles with a 0.2 inch radius.

14. Create a new sketch and draw circles for screw holes 3/32 in diameter and place them 0.204 inches away from the corner of the filet.

15. Extrude down into the hole sketches 1 inch deep.

16. Create a lid 0.098 inches thick with holes 0.204 inches away from the corners diagonally. The diameter of the holes should be 3/32 inches.

17. Save both files in stl. Format for 3D printing.

18. Print at Wendt and allow print to complete.

19. Remove the housing unit from the print bed carefully and clean up any support material using a small blade or file.

20. Make adjustments to the fit or openings if necessary.

Conclusions/action items:

Our final design changed from our initial by becoming bigger and changing number and size of hole for wires and switch for LED.

Matthew Niemuth - Dec 03, 2025, 8:03 PM CST

Download

Microcontroller_CAD_Desing.jpg (95.2 kB)

12/1/2025 - Microcontroller Box CAD Technical Drawing

Title: Microcontroller Box CAD Technical Drawing

Date: 12/1/2025

Content by: Matthew

Present: n/a

Goals: Create a technical drawing of our microcontroller box to showcase dimensions and different views.
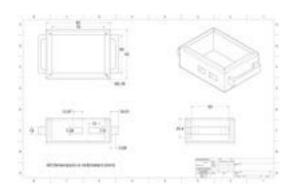
Content:

PDF below.

Conclusions/action items:

The technical drawing below showcases the front, side, top, and isometric view of our final microcontroller box CAD design.

Download

Microcontroller_Box_Technical_Drawing.pdf (132 kB)

9/26/2025 - Biosafety training

Matthew Niemuth - Sep 26,

Title: Biosafety and Chemical safety training documentation

Date: 9/26/2025

Content by: Matthew Niemuth

Present: Matthew Niemuth

Goals: Complete Biosafety training

Content:

Conclusions/action items: Biosafety and Chemistry safety training documented 9/26/2025

🟪 10/28/2025 - Intro to Machining Training Documentation

Matthew Niemuth - Oct 28, 2025, 3:58 PM CDT

Title: Intro to Machining Training Documentation

Date: 10/28/2025
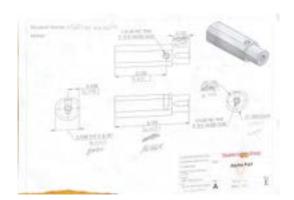
Content by: Matthew Niemuth

Present: N/A

Goals: Copmlete my intro to machining training.

Please view the pdf below of my Alpha Part piece dimensions sheet where all my final dimensions are that got checked off by Eric at the ECB. He also checked me off for completing Intro to Machining Training at the shop so I should be in there as completed.

Matthew Niemuth - Oct 28, 2025, 3:59 PM CDT

[Download](#)

Scanned_Oct_28_2025_at_3_55_09_PM.pdf (430 kB)

11/7/2025 - Kristin Myers Lecture: Why healthcare Needs More Engineers

Matthew Niemuth - Nov 07, 2025, 12:50 PM CST

Title: Kristin Myers: Why Healthcare Needs More Engineers

Date: 11/7/2025

Content by: Matthew Niemuth

Goals: Reflect on the speaker's ideas and record what she says.

Content:

Made her largest impact in career by chasing after the most difficult problems. Those are the ones that change the world

Chapter 1: The Foundation - Solve tangible problems, work hard & add value.

She swam at Madison, got her undergrade BME degree at UW- Madison, worked at Medtronic doing Marketing/Product Launch and Technical Sales, got her MBA at Harvard, Skyline Ventures startup healthcare company, Arboretum Ventures startup technology company. Worked venture capital that invested in Biotech and healthcare companies mentioned.

Chapter 2: Climb the Growth Curve - Combine EQ with IQ to multiply impact & reach

Aetna she was running a 350 person team with a billion dollar business that helped her build more opportunities. Chief of staff under a great leader is like business residency.

She now thinks about how she can make systematic change in healthcare where you can distribute care to people across geological barriers for example. Spent time at Blue Shield so healthcare is affordable and accessible and that patient experience is better than it is.

Big thing for her was you don't need to know your final destination - just follow hard problems and build skills that allow you to make an impact. Just make decisions in the context of what is important to you - that is how she feels she made her impact.

What does great healthcare look like?

- Improved provider Experience

- Improved Patient Outcomes

- Lower Cost of Care

- Improved Patient Experience

USA spends 18% of GDP about 5 trillion dollars on healthcare. We spend 2 times more than other well off countries.

The future of healthcare is an integrated ecosystem of health and care.

Healthcare needs better systems - and systems are what engineers build best.

Kristin's 5 Things

1. Work hard and Build Range - Take on the hardest projects, classes and experiences you can find. Effort and range are your foundation.

- If she was in our shoes, she would look for companies and places where you can be with other people. By range she means living in different places and seeing the different sides of things like business and manufacturing.

- Could find a job at university and talk about this is a job I did for a time and this is the impact it had.

2. Seek Diverse Exposure - Explore different sectors, teams and geographies. Gain perspective and learn how systems connect, not just how parts work.

3. Choose Your People wisely - Surround yourself with curious, driven, high-integrity people. They will shape who you become.

4. Know Your Values & Protect Them: Define what matters most - family/friends, health, career/impact, values - and make decisions that align.

5. Embrace Challenge & Keep Growing: Run towards hard problems. Growth lives on the edge of discomfort - where big impact starts.

- give yourself grace. You have made it far. Keep working hard and propelling yourself forward.

How to avoid burn out while working hard?

- use your energy flow. Notice when your energy is highest and work the hardest during those times. Take short breaks to prevent yourself from hitting a wall. Also get good at saying no to things, especially to the norm. Being able to let things go is important if you want to prioritize what is important to you like physical health and working out, time with friends/family, my relationship with God.

Conclusions/action items:

🟪 9/11/25 - The Biomechanics of Ski Jumping

SARAH KONG - Oct 06, 2025, 11:46 PM CDT

Title: The Biomechanics of Ski Jumping

Date: 9/11/25

Content by: Sarah Kong

Goals: Establish a baseline level of knowledge concerning the biomechanics of ski jumping

Search Term: Ski Jumping Biomechanics

Citation: H. Schwameder and E. Müller, "Biomechanics in ski jumping: A review," *European Journal of Sport Science*, vol. 1, no. 1, pp. 1–16, Mar. 2001, doi: https://doi.org/10.1080/17461390100071107.

Link: https://www.researchgate.net/publication/246473909_Biomechanics_in_ski_jumping_A_review

Content:

Kinematic Investigations of Hill Jumps:

Kinematic investigations specifically look at the separate phases of ski jumping: in-run, take-off, early flight, stable flight, and landing. For in-run, most experiments in the past have proved correlation between approach velocity and jump distance. The take-off phase is the most investigated phase typically because the significance of posture and velocity most directly affect jump distance. Additionally, correct takeoff timing is of central significance for long jump distances. Early flight is also very important to look at, specifically position angle. An investigation by Arndt et al. proves that the most important factors with early flight are a combination of a big forward learn of the upper-body, the lower body and the skis being in a locked position, and a big ski and leg opening after 17 m of flight. Need high knee-angle velocity, great torque during the take-off, and a small body/ski angle.

There are relatively few investigations of kinetics in ski jumping, most people look at the ground reaction forces (force plate insoles metric).

There are also vast limitations for collecting biomechanical data for ski jumping due to the great spatial scope of motion.

Summary or Significant Research Areas:

- Development of a feedback system for immediate evaluation of hill jump quality using kinematic and kinetic variables

- Analysis of musculoskeletal loading during ski jumps

- Examination of training drills with regard to their similarity to hill jumps with reference to their kinematic structure as well as the coordination pattern with the aid of EMG

Conclusions/action items: The things to look for most when utilizing the motion capture system are the angles of the jumper's body during in-run, takeoff, and the transition and upper body positioning to ensure maximized aerodynamic posture. Additionally, we could utilize the force plates to measure weight distribution when entering the in-run phase.

SARAH KONG - Oct 06, 2025, 11:13 PM CDT

Schwameder_MllerBiomechanicsinskijumping-AreviewEJSS111-16.pdf (282 kB)

10/23/25 Biological Benefits of Force Insoles in Ski Jumping

SARAH KONG - Oct 23, 2025, 10:00 PM CDT

Title: Biological Benefits of Force Insoles in Ski Jumping

Date: 10/23/25

Content by: Sarah Kong

Goals: Establish the biological benefits of force insoles in reference to our Ski Jumping training system.

Search Term: use of force reading insoles for injury prevention

Citation: H. Nagano and R. Begg, "Shoe-Insole Technology for Injury Prevention in Walking," *Sensors*, vol. 18, no. 5, p. 1468, May 2018, doi: https://doi.org/10.3390/s18051468.

Link: https://pmc.ncbi.nlm.nih.gov/articles/PMC5982664/

Content:

- With ski-jumping, athletes undergo repeated high-impact landings, so these force insoles that monitor pressure under the foot during takeoff and landing, these readings can reveal excessive or asymmetrical loading which leads to increased biological stress on joints, tendons, and foot structures.

- Additionally, when jumping of the ramp, optimizing which part of the foot is jumped off of can influence jump distance.

- Injury prevention is a huge part of the sport of ski-jumping, but the training system we're designing is more focused on performance improvement, so looking at pressure distribution at the moment of takeoff as well as possibly in-flight would be more beneficial. Pressure should be maximized at the moment of takeoff on the balls of the foot with each foot outputting relatively equal pressure.

- Although this article revolves around walking, the same principles can be applied to ski jumping just at a much more extreme level.

Conclusions/action items: Force insoles have typically been used in the past within sports for injury prevention as the parts of the foot where landing pressure is maximized can tell a lot about injury possibilities. However in the case of our project, we will need to use the insoles more as a timing and pressure distribution sensor for optimal jump distance.

9/16/25 - Ski Jumping Technology

SARAH KONG - Sep 17, 2025, 12:59 PM CDT

Title: Ski Jumping Technology

Date: 9/16/25

Content by: Sarah Kong

Goals: Learn in what ways technology is already utilized within the world of ski jumping and how we could possibly build off that foundation.

Search Term: technology for studying ski jumping

Citation: Y. Li, L. Liu, L. Xing, J. Chai, and D. Sun, "Progress in Ski Jumping Technology Based on Biomechanical Sport Research Methods," *Applied sciences*, vol. 14, no. 6, pp. 2281–2281, Mar. 2024, doi: https://doi.org/10.3390/app14062281.

Link: https://www.mdpi.com/2076-3417/14/6/2281

Content:

- wearable sensors are becoming more viable for tracking full sequences in real field conditions

- motion videos collection are key to analyzing the angular momentum necessary to achieve stable flight attitude, specifically in the takeoff process

- using wearable inertial measurement units like gyroscopes and accelerometers help determine a series of forces and calculate joint angles

- studies concerning ski jumping performance should emphasize the transitions between phases more as they are more technical and complex for ideal performances

- "Using computer simulations, Remizov developed an optimal flight control model for h-style ski jumping, and presented the optimal time history for the angle of attack to maximize flight distance" -> a model already exists

Conclusions/action items: The first step in our design process would be to consider what variables we want to look at when comparing the jumper to our expert model and then design a software that can utilize the motion captured videos to calculate those variable so there's a scalar comparison of the jumper and the ideal.

SARAH KONG - Sep 17, 2025, 12:48 PM CDT

Download

applsci-14-02281-v2.pdf (382 kB)

9/24/25 AI-Assisted Video Training System for Skiing

SARAH KONG - Sep 28, 2025, 9:09 PM CDT

Title: AI-Assisted Video Training System for Skiing

Date: 9/28/25

Content by: Sarah Kong

Goals: Learn what sport analytics systems already exist for skiing/ski jumping and see how we can differentiate our designs to improve upon what already exist

Search Term: Norway ski jumping biomechanics technology training system

Citation: I. Greenwood, "Is This The Future of Ski Racing? Cutting Edge Training Software Launches Ahead of Olympics," *Powder*, Sep. 05, 2025. https://www.powder.com/news/ai-ski-training-video-software (accessed Sep. 29, 2025).
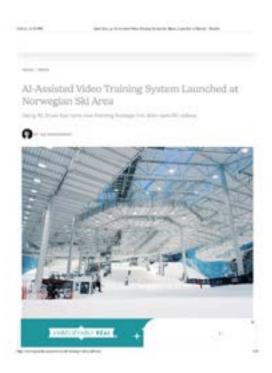
Link: https://www.powder.com/news/ai-ski-training-video-software

Content:

- Snow Eye is an AI-Assisted video training system for skiers that takes raw training footage and analyzes it to output feedback for the user

- In reference to our current project -> if we can code a software that can detect and separate out the different phases of ski jumping (in-run, takeoff, flight, and landing), we can align them with force and motion data gathered either from real time or literature, and deliver feedback based on the comparisons

- the article references how filming skiers often takes up more resources and time than it should, so having this AI-assisted system lightens the load on the coaching staff and imporves athletic ability

- while the article doesn't go too in depth about how to AI actually works, it presumably measures the athletes performance against an ideal and then outputs advice from that comparison, which is exactly what we plan to design

Conclusions/action items:

SARAH KONG - Sep 26, 2025, 12:52 PM CDT

Download

Snow_Eye_an_AI-Assisted_Video_Training...or_Skiers_Launches_in_Norway_-_Powder.pdf (11.4 MB)

9/29/25 Force Plate Insoles

SARAH KONG - Sep 29, 2025, 11:02 PM CDT

Title: Force Plate Insoles

Date: 9/29/25

Content by: Sarah Kong

Goals: Research force plate insoles, specifically lookin gat costs and number of sensors used

Search Term: force plate insoles in sports

Citation:

Condé. "These Smart Insoles Fixed My Running Form—and My Aching Hip." *Wired*, 5 Mar. 2021, www.wired.com/review/nurvv-run/.

Smart-Insole." *XO-NANO Smartfoam*, 22 Sept. 2025, www.xonanosmartfoam.com/xo-sole-smart-insole/. Accessed 30 Sept. 2025.

Link:

https://www.wired.com/review/nurvv-run/

https://www.xonanosmartfoam.com/xo-sole-smart-insole/

Content:

Wearable Insole could Prevent Shin Splints:

- features 16 high-precision sensors

- sensors 22 g each and capture data feet at 1000 times per second

- soft, light, breathable, fit any regular running shoes

- 5+ hours of operation without charge

- regular metrics: distance traveled, duration, pace, elevation, and calories

- unique metrics: cadence, step length, foot strike, pronation (natural inward roll of the foot), and balance

- data is then fed into the NURVV Run coaching app to show a complete picture of the user's running technique

- for $300, two insoles and two trackers that mount outside of the shoe

XO-NANO Smart Insole

- 8 distinct force measurement zones

- 9-axis inertial measurment unit

- less than 100 g with 12 hr battery life

- "designed to deliver lab-grade biomechanics"

- measures ground reaction forces

- usually $5,000, on sale for $2,500

Conclusions/action items: There are many different force plate insoles on the market, it just depends on what metric we're searching for and how much we're willing to pay. I believe the XO-NANO ones match up better with what we're trying to do with the ski jump trainer, but they cost way too much.

Sarah Kong/Research Notes/Sensor Types/11/24/25 Piezoresistive vs. Capacitive Sensing

169 of 230

11/24/25 Piezoresistive vs. Capacitive Sensing

SARAH KONG - Dec 08, 2025, 10:51 PM CST

Title: Piezoresistive vs. Capacitive Sensing

Date: 11/24/25

Content by: Sarah Kong

Goals: Compare the two types of sensors and ensure piezoresistive is the best for the purposes of this project

Search Term: piezoresistive vs capacitive sensors for measuring ground reaction forces

Citation:

[1] AVnet, "Capacitive vs Piezoresistive vs Piezoelectric Pressure Sensors | The Design Engineer's Guide | Avnet Abacus," *Avnet.com*, 2015. https://my.avnet.com/abacus/solutions/technologies/sensors/pressure-sensors/core-technologies/capacitive-vs-piezoresistive-vs-piezoelectric/

[2] ES Systems. "MEMS Capacitive vs Piezoresistive Pressure Sensors – What Are Their Differences?" *ES Systems - Pressure & Gas Flow Sensor Solutions*, ES Systems, 24 Sept. 2020, esenssys.com/news/capacitive-piezoresistive-pressure-sensors-differences/

Link:

https://my.avnet.com/abacus/solutions/technologies/sensors/pressure-sensors/core-technologies/capacitive-vs-piezoresistive-vs-piezoelectric/

https://esenssys.com/news/capacitive-piezoresistive-pressure-sensors-differences/

Content:

Piezoresistive Sensors:

- Measure change in resistance under pressure
- Extremely simple electronics: voltage divider -> ADC
- Material is flexible, cuttable, and works with basic copper tape electrodes
- Sensitive enough for human-foot pressures
    - Velostat is good piezoresistive sensor, measures pressure as compressed pressing the carbon particles closer together increasing the formation of conductive pathways so resistance decreases as pressure increases
- Output is linear with pressure
- Relatively long life, but there can be problems with the adhesives at high temperatures and overpressure

Capacitive Sensors:

- Measure change in capacitance (ability of an electrical component to store enegery in an electric field) as a material compresses
- Very stable and low-power, but:
    - Requires complex readout circuits
    - Requires shielding to avoid noise
    - Needs precise electrode space and stable dielectric layers -> silicone/foam would work as the dielectric layer making them the pressure-sensing element through the equation $C = E(A/d)$ where E = permittivity of the material, A = electrode area, and d = thickness of the dielectric layer so as the foam/silicone compresses, d would get smaller and C would increase
- Exhibit low hysteresis and good repeatability of measurements with low temperature sensitivity

Comparison in context of our project:

Velostat as a piezoresistive sensor is the most cost-effective and efficient option for this project because the material itself is the sensor, no special geometry and extreme technology needed. A resistor and microcontroller attached to the Velostat + some complex circuitry is enough for the Velostat to measure pressure within the human pressure range versus capacitive sensors which are more precise but require dedicate capacitance-measure IC, shielded layouts, and much higher manufacturing precision.

Conclusions/action items: While capacitive sensors may have been a more precise option, the complexity and cost to acquire the parts and fabricate them did not fit within the realm of possibility for this project. Velostat works well for the purposes of measureing ground reaction forces for a human jumping and is cost-efficient.

9/26/25 Combination of Force Plate Insoles and Kinovea

SARAH KONG - Sep 28, 2025, 8:58 PM CDT

Title: Combination of Force Plate Insoles and Kinovea

Date: 9/28/25

Content by: Sarah Kong

Present:

Goals: Combine motion capture and force plates in the most efficient way to gather ski jumping data

Content:

- Force plate insoles can go inside the ski boot and measure the ground force reaction at the moment the user jumps

- this would help the user understand how much force they should be outputting when jumping and establish what methods/techniques help them maximize their jump force
- more efficient because the plates move with the user instead of having to somehow build a force plate into the ski hill

- Kinovea is video annotation tool designed for sports analysis in which we can input slow-mo videos of the user jumping (Caleb's idea) since the part we're trying to analyze is the 1-2 second transition between the in-run and takeoff phase

- features utilities to capture, slow down, compare, annotate, and measure motion in videos
- would allow us to analyze the shin angles while in-fligh, as well as the thigh-knee-calf angles while in-run

Conclusions/action items: The combination of these two tools would prove to be a very efficient and portable product in which the user wouldn't have too much difficulty using. Additionally, both these utilities help us gather the metrics we need most effectively without interfering with the user's technique.

10/9/25 Force Insole Fabrication

SARAH KONG - Oct 10, 2025, 1:30 PM CDT

Title: Force Insole Fabrication

Date: 10//9/25

Content by: Sarah Kong

Present:

Goals: Establish a solid fabrication plan for the force insoles using Bambu Studio and following these steps: https://www.instructables.com/Wearable-Smart-Sensing-Insole/
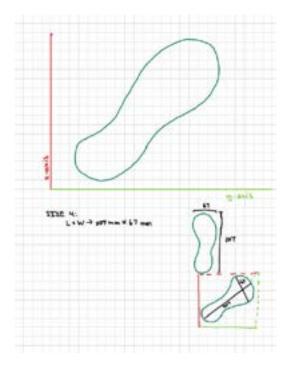
Content:

Since we are trying to go back to the ski hill sometime next week, I would like to at least have one or two prints of the template done before then so we can see how everything fits in the boot. My proposed plan is:

1. Print one practice template based on my conversions (attached below)
    1. Order materials necessary to construct the force insoles (ask about invoicing the client)
2. Measure the practice print to see if the calculated dimension match up with the desired length
3. If practice print is not the right length (very likely), play around more in Bambu Studios and print another template
4. Bring both templates to Blackhawk Ski Club and see how they fit in the boot
5. Take notes and measurements at the ski club
6. Bring templates back and either print new ones based on metrics gained from ski hill or print the other foot of the template that worked out
7. Use template and start putting sensor together

Conclusions/action items: Constructing our own force plate insoles is a very doable task if we are able to plan everything accordingly and timing works out.

SARAH KONG - Oct 09, 2025, 4:41 PM CDT

[Download](#)

size_conversions_math.pdf (3.68 MB) My work to convert the Bambu Studio file to a size 4 shoe using the dimensions of the given template (US Men's 8) and the actual length of the sole from a 3D view of the finished print.

10/14/25 Pressure Sensors + Arduino

SARAH KONG - Oct 17, 2025, 12:40 PM CDT

Title: Pressure Sensors + Arduino

Date: 10/14/25

Content by: Sarah Kong

Present:
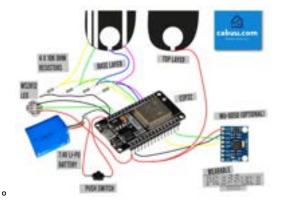
Goals: Learn about the fabrication process of pressure sensors and how to connect the sensors to arduino for an understandable output.

Content:

Fabricating the Force Insoles:

https://www.instructables.com/Wearable-Smart-Sensing-Insole/

1. 3D Print force insole template with 1 mm thickness in PLA

2. Use copper tape as traces to connect the sensing circuit. Traces must not touch each other and extra tape at the sensor locations to be folded back on itself. Measuring force/pressure.

3. Sensors are made using Velostat, an electrically conductive materials whose resistance changes as it is flexed or compressed. Cut into small squares or circles and secure each piece in place on the template using copper tape. Sensors must not touch one another or any neighboring traces.

4. Solder some thin gauge wire directly to the copper tape at the heel of the insole. These wires will carry data from each sensor to the micro-controller so they need to be long enough to reach to micro-controller attached to the outside of the boot. Secure the wire in place using hot glue and trim off any excess copper tape.

5. For a Velostat sensor to work, it must be insulated and sandwiched between two conductive layers (copper tape in this case) as it is a carbon-impregnated plastic so its electrical resistance changes predictably in response to physical pressure. The copper serves as the two contact points or electrode needed to complete the circuit and measure the material's variable resistance. Because of this, we must insulate everything but the Velostat on the first layer so put electrical tape all over but leaving the sensors mostly uncovered.

6. Then put copper wire over the top of the tape making sure copper tape makes contact with the sensor and it extends to the heel. Solder a single cable at the heel long enough to reach the micro-controller. Use hot glue gone over the soldered connection.

7. Connect the microcontroller, this part involved Arduino and connecting the individual wires to the micro-controller using a proof board.

Arduino Connections and Code:

1. From a YouTube video about hooking up a pressure sensitive Fabric with Velostat and Conductive Fabric, this is the Arduino code: https://gist.github.com/sshadmand/34a2f73e48a731c3c2e86b2171d6c41e
2. 3D-Print the Housing for the microcontroller and battery
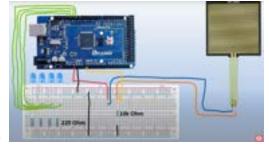
While the instructables.com website details how to connect everything to microcontroller, their method required WiFi which we do not have access to out on the ski hill so for these initial data collection phases, we will probably collect as much data as we can there and then process it later when we

get access to WiFi. In the later stages of this project, we will have to figure out how ot process the data at the ski hill so jumpers can get almost immediate feedback. From my understanding, I think using an Arduino kit to fabricate the micro controller would be something like this:

1. Connect Velostat to the 5V pin using an alligator clip, one side clipped on the Velostat and the other on the Arduino. This will be difficult to do within the ski boot, so instead I suggest we use a wire that connects to the copper tape at the heel of the foot and stick the other end of the wire in the 5V pin hole. This wire would be located on the top layer of the electrical tape. The four wires on the middle layer of the force insole connected to 4 separate 10K Ohm resistors. The colors dictate what resistance, need to locate correct colors. Each resistor must be the same.

2. This is what the connection of a force sensor to Arduino, ignoring the LED part with the green wires. This part involves using a bread board just to check the wire connection and make sure everything works before soldering. The picture below demonstrates what one of our Velostat sensors would look like. The blue wire from the Velostat is connected to the red wire on the breadboard as each column on a breadboard is connected. This red-blue connection goes to the 5V on the Arduino. The orange and yellow wires are also connected via the breadboard which goes to the A0 pin on the Arduino which will take the data from the sensors and reads it. This data will be intrepereted using the Arduino IDE code (later problem). This yellow-orange connection is also connected to a 10k Ohm resistor which will limit the flow of electrical currents to protect the Arduino pins. On the other side of the resistor is another black wire connected to the negative rail. Theres another black wire that connects the two negative rails making sure the current flows from both sides. Lastly, there's another black wire connected from the circuit to ground.

3. After testing all the connections through the bread board, we can then solder the wires together and 3D-Print a house for the Microcontroller than can sit securely on the outside of the boot.
4. 6:08 of this video: https://www.youtube.com/watch?v=vUcZmnbD2_8&t=169s details the code used to interpret this data which we will also be using, but a few tweaks may be needed in the future.
5. change in voltage -> pressure distribution

Conclusions/action items: After combining a bunch of different youtube tutorials and my own personal knowledge about Arduino and breadboards, I believe I have a solid plan for fabricating these force insoles in a way that will work for this stage of the project. The specific connectivity demonstrated in the steps in paragraphs above should work to capture ground reaction forces, but I do need to further research what exactly this circuitry will be measuring and what the code from the video interprets the data as.

11/17/25 Velostat as a Pressure Sensor: Function + Efficiency

SARAH KONG - Dec 08, 2025, 10:55 PM CST

Title: Velostat as a Pressure Sensor: Function + Efficiency

Date: 11/172025

Content by: Sarah Kong

Present:

Goals: Research and evaluate Velostat as a pressure sensor in regards to the purpose of this design as a part of a ski jumping training system

Content:

Velostat is the most effective and cost-efficient material for this pressure-sensing project because it is naturally piezoresistive, inexpensive, flexible, and extremely easy to integrate into wearable systems like smart insoles. Unlike capacitive sensors, which require precise electrode spacing, shielding, and specialized capacitance-measurement circuitry, Velostat only needs two electrodes and a simple voltage divider to function. It can be cut into any geometry, laminated between layers of foam or fabric, and reliably detect the range of pressures produced during walking or standing. Its low cost and durability make it ideal for prototyping multi-sensor arrays without dramatically increasing project complexity or budget. For our engineering project, Velostat provides the best trade-off between accuracy, ease of fabrication, responsiveness, and affordability.

Velostat works through the piezoresistive effect: it is a polyethylene film loaded with microscopic carbon particles that form a loose, semi-conductive network. When pressure is applied, the material compresses and the carbon particles move closer together, increasing the number of conductive pathways inside the film. This causes the electrical resistance of the material to decrease as pressure increases. By placing Velostat between two conductive layers (such as copper tape) and wiring it into a voltage-divider circuit, these resistance changes convert directly into measurable voltage changes that correspond to force or pressure. This simple and reliable mechanism makes Velostat an ideal sensing medium for low-cost pressure detection in wearable or embedded systems.

Conclusions/action items: Velostat is the best cheap option for this project as it does the job and doesn't require too many additional elements to make it work/

9/13/25 Biosafety and Chemical Safety Completed Training

SARAH KONG - Sep 26, 2025, 1:00 PM (

Title: Biosafety and Chemical Safety Completed Training

Date: 9/13/25

Content by: Sarah Kong

Present:

Goals: Show proof of completion of Biosafety and Chemical Safety (OSCHA Lab Standard) Required Training

Content:

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

This certifies that Sarah Kong has completed training for the following course(s):

Course	Assignment	Completion	Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2024-2025	9/13/2025	9/13/2030
Chemical Safety: The OSHA Lab Standard	Final Quiz	9/13/2025	

Data Last Imported: 09/26/2025 12:54 PM

Conclusions/action items: Biosafety and Chemical Safety Training completed.

10/17/25 Introduction to Machining Training

SARAH KONG - Dec 10, 2025, 10:12 PM CST

Title: Introduction to Machining Training
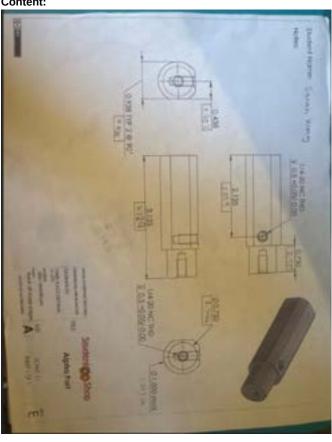
Date: 10/17/25

Content by: Sarah Kong

Present:

Goals: Complete intro to machining training

Content:
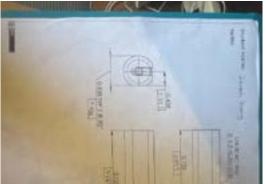
Conclusions/action items: Intro to machining training complete through the use of the lathe and mill to make an Alpha part.

SARAH KONG - Dec 10, 2025, 10:10 PM CST

Download

annotated-1765126530.455334.jpg.pdf (2.72 MB)

9/26/25 BPAG Meeting Notes

SARAH KONG - Sep 26, 2025, 12:47 PM CDT

Title: BPAG Meeting Notes

Date: 9/26/2025

Content by: Sarah Kong

Present:

Goals: Learn about what the role of BPAG entails

Content:

- get client to purchase stuff for us

- must okay purchases with client prior to purchase

- any purchase over $1000 must have departmental approval

- all original receipts in notebook -> for E-Reimbursement LAST RESORT

  - invoice from order

- table of expenses in notebook, progress report, and report

  - shrink likes, do not stretch cells over multiple pages
  - links must be clickable

- not rehab project or industry prepaid, client or us pay

- BPAG is the only one paying and seeking reimbursement, only I will get reimbursed

- if buy from amazon, show product is not available in ShopUW vendors first

- $50 budget per team -> Account Name: BMEDesign

  - (if exceeded, talk to Dr. Puccinelli, client can setup own account if needed)

Conclusions/action items: Have client buy things, make sure everything is approved. There are places products an't be ought from. Keep all receipts, seek reimbursement before poster session.

SARAH KONG - Sep 26, 2025, 12:19 PM CDT

[Download](#)

BPAG__Purchasing_Guidelines_for_BME_Design_Teams.pdf (738 kB)

Current Expense Spreadsheet

SARAH KONG - Nov 19, 2025, 12:28 PM CST

Title: Current Expense Spreadsheet

Date: Present

Content by: Sarah Kong

Present:

Goals: Display expense spreadsheet

Content:

Link to spreadsheet:

https://docs.google.com/spreadsheets/d/1_kLPzdNUgeK5qO5MscxHWwflzIzkK6B-OuzJDpwLuqQ/edit?usp=sharing

Conclusions/action items:

Keep updating spreadsheet with 3D-printing and material expenses

11/7/25 Tong Lecture: Kristin Myers

SARAH KONG - Nov 07, 2025, 12:57 PM CST

Title: Tong Lecture: Kristin Myers

Date: 11/7/2025

Content by: Sarah Kong

Present: Everyone

Goals: Learn about BME career paths and entrepreneurship

Content:

- Building something that matters why healthcare needs more engineers
- Run towards the hard problems, they are the ones that change the world
- 4 internships, 4 co-ops -> get started early
- Lots of jobs and different types of career paths:
  - Worked as Medtronic for four years then when to Harvard to get an MBA, then moved to NorCal to work in Venture Technology
  - At Aetna, very troubled business at the beginning but she jumped in to take on the role and ran a 350 person team overnight -> from that built more and more opportunities
- When the pandemic hit, changed everything at Aetna was an urgent practice where everything was essentially an emergency
  - Had to furlough 50% of the to account for the money loss from the pandemic
- First part of the career about herself, how to establish herself and gain experience while second part was about combining IQ with EQ and working to help others
- How do you make systematic change?
  - how to make healthcare affordable and accessible for people
  - how to improve patient experience -> amazing experiences at apple but in more important places such as healthcare, that effort and money isn't there
- Quadruple Aim: Improved Provider Experience, Improved Patient Outcomes, Improved Patient Experience, Lower Cost of Care
- It's become very hard to be a physician in this country, smaller and smaller percentage of time is about patient care
- 18% of GDP $5.3 Trillion on Healthcare
- US ranked last on equity, access, & outcomes, Lower life expectancy, Women birth mortality rate increase
- Underlying Challenges: misaligned incentives, fragmented financing & regulation, data silos & legacy IT, inequities (10-15 year gap between zip codes)
  - the degree to which ones zip code dictates about level of care and income level will be is crazy
- Healthcare is broken because it was never designed to be one system
- What if we build an integrated system to enable health and wellness for all?
  - making it so the doctor is rewarded for the amount of time and effort put into thinking about a long-term health plan for a patient
  - outcomes rather than services
- To build a better health care system, the roles of engineers:
  - design thinking, system thinking
  - interconnected connection of the data
  - process optimization, design & iteration, analytical rigor (data-driven analysis & decision making), systems thikning (seeing how the parts connect in the big picture, and way more
  - "Healthcare needs better systems. And systems are what engineers build best."

1. Work Hard & Build Range: Take on the hardest projects, classes, and experience you can find. Effort and range are your foundation.
    1. Look to be in an actual office rather than online or hybrid
2. Seek Diverse Exposure: Explore different sectors, teams, and geographies. Gain perspectives and learn how systems connect, not just how parts work
    1. Don't have to be stuck in a cubicle, know how you work best and work toward that goal
3. Choose Your People Wisely: Surround yourself with curious, driven, high-integrity people. They will shape who you become

1. Think about the 5 people you spend the most time with and how they impact your behavior -> they have a way of shaping your trajectory

4. Know you Values & Protect Them: Define what matters most - family/friends, health, career/impact, values - and make decision that align
   1. Overtime, different priorities take hold, health is a very foundational thing, sleep!!!, have people around that offset your bad habits

5. Embrace Challenge & Keep Growing: Run towards hard problems. Growth lives on the edge of discomfort - where big impact starts
   1. Operate from curiosity and wanting to take on big things and embrace them -. feel good bout the place we're all in right now

Questions:

Best way to avoid burnout?

Block calendar, take a break during lunch to avoid running into a wall, work fro 1.5 hours, then late afternoon is time to work with others, like mentorship and reconnect with others. Learning to say no, lots of social opportunities, if it was tomorrow and you wouldn't say yes don't say yes. We can only do so much + peace + being willing to let some things go.

Solution comes form proving primary care actually provides outcomes at a lower cost, giving consumers transparent data, consumers making better decision based on this transparency

Isn't it hard for a patient to choose their care if there's only one place they can get it?

US drug pricing versus other countries, lots of significant changes from drugs -> an example direct to consumer

Experience regret the least?

Going to business school, she went 5 years post-grad -> Fundamentally knew she was interested in general management and business, figuring out how to deconstruct things and develop a strategy to put them back together. Inspired her to think about how she might change the world -> people will see where you went to school and a lot of credibility from that, paring business adn engineering was amazing, made her the wild-card candidate

Conclusions/action items: Learned a lot about what it takes to be a leader in the healthcare industry as a BME major. Healthcare needs engineers, we bring a new perspective and can make the systematic changes that need to be made.

9/10/25 - Lecture 1: BME Career Prep

KENNETH SUN - Sep 10, 2025, 2:07 PM CDT

Title: BME career prep by Stephanie director of career services

Date: 9/10/25

Content by: Kenneth Sun

Present: Kenneth Sun

Goals: Learn more about internships and opportunities for PT opportunities and jobs (PT Aide?)

Content:

- ECS.wisc.edu - Policies and Resources (Job tracker excel spreadsheet)
- Find jobs on primary sources like company website and Handshake
- Going to career fair helps you meet a real person and now you have a contact to follow up!
- Resumé is a summary
    - Tailor resume to different jobs
    - Design projects without years or semesters - What did you do?
- Cover Letter Tips
    - Outline:
        - Intro: who you are, applying for, where you found it, and "thesis" statement
        - Paragraph about 1st point/experience
        - Paragraph about 2nd point/experience
        - Why this employer/role + closing/next steps
- Introduce yourself
- Why you are talking to them
- Softball/handoff question

Conclusions/action items:

Ask Mrs.Levy about Engineering internships and how they are viewed within PT program admissions. Do they get less importance in terms of experiences since it isn't directly PT related?

🧊 9/17/25 - Lecture 2: BME Leadership Styles

KENNETH SUN - Sep 17, 2025, 1:58 PM CDT

Title: BME Leadership Styles

Date: 9/17/25

Content by: Kenneth Sun

Present: Kenneth Sun & Caleb White

Goals: Learn more about leadership to make sophomores more comfortable and prepared

Content:

Important qualities of a leader:

- Assertive, Aura, Communication, Understanding, Openminded
- Self awareness & vision
    - Need to be transparent as well/open to feedback
- Decision making

Leadership levels:

- Personal
    - self awareness and management
    - goals
- Interpersonal
    - responding to others, active listening, building trust
- Team
    - Lebron James
    - facilitate team interactions
- Organization
    - Adam Silver

Leadership Styles:

- Power
    - Leadership = Power
    - Only certain people have what it takes
    - Hierarchy, authority, command - be in control of the team
- Servant
    - Leadership = Mutual Service
    - Needs of followers are most important
        - Jesus
    - Listening/understanding, empowerment, etc
- Authentic
    - Leadership = Authenticity
    - Emotional intelligence
    - Building self esteem and self awareness

- create authentic relationships
- Leadership doesn't require a job title, it is a skill you can develop anytime and anywhere

Conclusions/action items:

 It's important to make sure everyone on the team feels comfortable and engaged. It takes a lot of communication to be able to lead your team into efficient work. Even managing emotions is something that is required within specific teams so ego's don't overwhelm the team dynamics.

9/24/25 - Lecture 3: BME Mentoring

Title: BME Mentorship

Date: 9/24/25

Content by: Kenneth

Present: Kenneth

Goals: Learn more about why we are mentoring the BME 200 students and how to improve our mentorships

Content:

- Peer mentors are much more approachable than high up faculty
    - Allows mentees to ask more questions
- Transferable skills that come with mentoring students helps with career and opportunites
- Increased patience
- Build positive habits
- Help identify gaps in your knowledge
- Sense of accomplishments
- Stop talking so much and allow the sophomores to talk more
- React to ideas and not the person
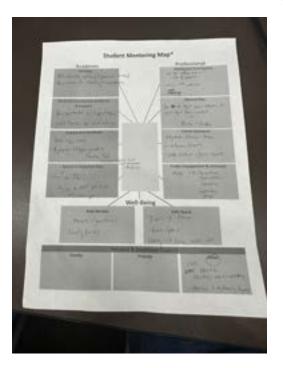
Mentor Map:

- I wish I knew how the 300 students are also learning

- I wish I knew I how fast the design project goes by

- I wish I knew how to manage client relationships

- I wish I knew how important the documentation was and to be consistent with the entries

Conclusions/action items:

Figure out times to tell the sophomores this advice. Maybe sprinkle this information during group meetings or even text them if they ever need advice.

10/1/25 - Recycling and Environmental Impact

KENNETH SUN - Oct 01, 2025, 1:48 PM CDT

Title: Environmental Impact Lecture

Date: 10/1/25

Content by: Kenneth Sun

Present: Kenneth Sun

Goals: Learn more about how engineering views environment and how to protect it

Content:

- Environmental thinking with life cycle assessment
  - carbon footprint
  - disposal/recycling
- Coffee Pods and regular coffee have same environmental impact
  - Coffee pods may have plastic but energy usage from regular coffee cancels it out
- How bad are these coffee pods really?
  - Plastics are an issue but for carbon footprint either method doesn't actually matter.
- exam table paper - doesn't actually help with infection reducing if you disinfect the table.
  - They could save money and environmental impact
  - These are easy decisions to make when connected with economic factors.
- Speculums for vaginal exams
  - One time use and disposable (waste?) vs metal ones (autoclaved)
  - Looked at weight of plastic and stainless steel and see how that corresponds to environmental effect
  - stainless takes more energy to manufacture and has higher upfront footprint
    - if you have lots of exams then metal but only a few than plastic is better for environmental footprint
- How do we use tools to engineer more sustainable world?
  - Using nanoscale silver (antimicrobrial)
  - Nanoscale silver in a tube and you throw it in the wash with your gowns - coats gowns with antimicrobrial benefits.
    - After wash 12 you hit your environmental breaking point - makes more sense to use reusable gowns

Conclusions/action items:

It is very important to consider multiple factors when figuring out if a decision is actually helping environment or is there something else actually offsetting it. For example with tesla cars, you have no gas but the environmental impact of actually producing the battery may offset that.

10/8/25 - Patent, IP, and WARF

Title: Patent, IP, and WARF lecture

Date: 10/8/2025

Content by: Kenneth Sun

Present: Kenneth Sun

Goals: Learn more about creating patents for new products.

Content:

1. WARF works at the interface of facilitating IP and commercial license
2. IP licensing
3. Industry-sponsored research
4. Consulting arrangements
5. Fee for service

4 IP
1. Patents
2. Copyrights
3. Trademarks
4. Trade Secrets
5. Other
    1. Biomaterials
    2. Technique
    3. Data

Non-Patent IP
1. Software copyright
2. Protection for names, logos, etc (trademark)
3. Trade Secrets (coca-cola, contact list, etc things that have value as a secret)

Patents
- Property right granted by governmental agency
- Three Types of Patens
    - Design (15 year term limited to ornamental features)
    - Plant (New, 20-year term, asexually reproducing)_
    - Utility
        - Provisional (1 year place holder)
        - Non-provisional (20-year term, can claim priority to a provisional)
            - Issued for new and useful processes
            - 20 years from the date that you file for the patent (takes 2-5 years to issue)
            - 30k for attorney fees - 90% of patents issued by USPTO are non-provisional utility patents

Requirements to Patent:
1. 101 - Eliigible; cannot be a product of nature abstract idea, or natural phenomenon
2. 102 - Novel: Must be new
3. 103 - Non-obvious; it cannot be simple modification or combination of exiting concepts
4. 112 - Enabled and Described; Must provide enough detail to teach others how to make or use the invention

Disclosing an innovation to WARF:
1. Disclosing
    1. Describe the innovation
    2. Identify applications and potential applications

      3. Name contributors (inventors and authors)

      4. Provide funding and public disclosure details

   2. Meeting with WARF

      1. Discuss the innovation in more detail

      2. Ask questions about WARF and patenting processes

      3. Discuss next steps

Medical Device Considerations

1. Insurance , applications of use, need for market

Benefits to Company

Reduced R&D cost, improved time to market, opportunity to intervew markets and expand your company quickly, new features

Determine values: Technology application, key selling poins

Conclusions/action items:

WARF controls UW IP, but they'll fund filing if it's promising. Keep documentation airtight, file before demoing, avoid overreliance on buzzwords, and make the claims about measurable biomechanical performance feedback for ski jumping and related sports. This is the cleanest route to protect the idea while still letting it evolve into something publishable or licensable later.

10/15/25 - Bioengineer it, Protect it

KENNETH SUN - Oct 15, 2025, 2:05 PM CDT

Title: Patents and lecture from BME alum - Intellectual property lawyer

Date: 10/15/25

Content by: Kenneth Sun

Present: Kenneth Sun

Goals: Learn more about other careers like Law that BME alum can do

Content:

So many legal career paths as engineers in IP based context:

1. Technical advisor - Stem
2. Patent agent - Stem + Patent
3. Patent examiner - Stem
4. Patent attorney - Law + Stem
5. Patent Litigator - Law
6. Etc

What skills are required in Engineering to IP:

- Lots of research - determine if invention is truly new
- Lots of technical writing - engineers are the best litigation drafters because we write very efficient
- Communication - Already very good with the amount of client and team communication we get in design classes
- Creativity - Problem solving 101, need to be able to create competitive products

IP ownership in BME industry:

Startup - you own IP; if you file early and use NDAs and document development

Company/University - Disclose before publishing; university company owns the IP you can get licensing opportunities.

Timing and Publication:

Publish before filing and offers for sale = lost patent rights abroad and possible loss of rights in the US - cooked

First to file system (NOT first to invent)

Keep invention notebook

Trademarks - Branding

Copyrights - Creative works

Trade secrets - Property right

Conclusions/action items:

Lots of detail and things to consider with IP. Very important job and something that engineers may not think about until they get screwed over by infrigement or litgation

10/22/25 - BME advising post grad planning

KENNETH SUN - Oct 22, 2025, 1:56 PM CDT

Title: Part two post grad planning

Date: 10/22/25

Content by: Kenneth

Present: Kenneth

Goals: Get some advice for what to do in the future

Content:

Three letters of references - 3 Strong ones

Prepare for MCAT or GRE - summer before senior year

Masters/Phd programs:

- Masters (1 year) - Stepping stone or delay life before full adult
  - 70 industry, 20 med school, 10 other programs
  - Perfect for rewriting your story, change directions or fill in gaps in resume
  - Good for gap year before medical school
  - Different options:
    - research masters
    - accelerated masters
- Doctoral, PhD
  - Independent researcher
  - Write research grants
  - Work in academia
  - Lead projects in industry, startups, and consulting - wisolve.org
  - Network!:
  - Conference, conference, conference!
  - Utilize your lab PI
  - build your resume
    - REU
    - research or honors in research
- PT school/Medical School
  - Lots of pre-reqs

Conclusions/action items:

Lots of requirements available, just make sure you are prepared and are able figure out which path you want to do.

10/29/25 - Regulation

KENNETH SUN - Oct 29, 2025, 1:54 PM CDT

Title: Regulation or no regulation, thats the question

Date: 10/29/25

Content by: Kenneth Sun

Present: Kenneth Sun

Goals: Learn about regulation for drugs and devices

Content:

- FDA determines if a device's benefits outweighs the risks - Not necessarily the safety of it. Nothing can be categorized as safe anything can be dangerous.
    - Class 1, Class 2, Class 3
    - Class 1: Tongue depressor (Low risk)
    - Class 2: Blood pressure cuff - Need to go thru 510k or 510k De Novo pathway(Moderate risk)
    - Class 3: Pacemaker - HTE pathway or PMA pathway (High risk)
- 510K De Novo - No predicate device but can become a predicate device
- 510K any device like previous 510 K De Novo approved devices can use the old approved device as a predicate
    - Only test what has changed in your design
- Cardiac Pacemakers at first had no regulation at all. Not even IRB
    - Surgeon made decision - the pacemaker was nickel material. Engineer said pulse generator for years but lasted for only 6 weeks but it kept getting cooked. Subject had 28 pacemakers
- Dalkon Shield started FDA regulation: women's implant contraceptive - Went straight to market with no oversight. Didn't stop pregnancy at all and lots of complication
    - Lots of safety events - Maternal death, septic pregnancy, etc
    - How did the company get the data and know what was wrong. Companies had incentive to ignore and not look into this
    - FDA comes in to regulate and avoid this situation
- Some really bad regulation stories like Phillips CPAP don't get out as much and results in no change!

Conclusions/action items:

Regulation takes lots of form but whats most important is its specificity to different situations. Some situation require more regulation while others may not need any extra and in fact may need less or removed ones.

11/5/25 - FDA approval

KENNETH SUN - Nov 05, 2025, 2:33 PM CST

Title: FDA Approval Process

Date: 11/5/25

Content by: Kenneth Sun

Present: Kenneth Sun

Goals: Learn about how to go from Ideation to approval

Content:

FDA Regulatory Framework (U.S.):
• The FDA oversees multiple divisions:
• Device: Pre-Market Approval (PMA), 510(k), IDE (Investigational Device Exemption)
• Drug (CDER): IND (Investigational New Drug), NDA (New Drug Application)
• Biologic (CBER): IND, BLA (Biologics License Application)
• Gene delivery, genome editing, and cell therapy are becoming more common but still less approved overall
• Most interactions happen at the FDA guidance level

Regulatory Hierarchy:
1. U.S. Laws passed by Congress
2. FDA Regulations (FDA interpretation of those laws)
3. FDA Guidance (how the public should interpret the regulations)

Key Acts:
• Federal Food, Drug, and Cosmetic Act
• Public Health Service Act
• 21st Century Cures Act
• CARES Act

351 vs 361 Regulation:
• 361: Product taken from a patient and put back into the same patient for the same use, minimally manipulated, low regulation, low barrier to entry
• 351: Product not homologous or more than minimally manipulated, requires full regulation (BLA), high barrier to entry, must prove potency, purity, and safety

Steps to classify 351 vs 361:
• Minimally manipulated?
• Homologous use?
• Combined with another article (e.g., preservative or storage agent)?
• Systemic effect or dependent on metabolic activity?
• If any "no," usually 351

Target Product Profile (TPP):
• A living document that defines the vision of a therapeutic product
• Like a PDS but for therapeutic devices

TPP Components:
• Core: indication, patient group, efficacy, safety, dosage, route of administration
• Clinical Development: study pathway, cost, risk, timeline
• CMC (Chemistry, Manufacturing, Controls): purity, stability, shelf life, biocompatibility

Key Questions:

• Will patients and prescribers want it?

• Will regulators approve it?

• Will payers reimburse it?

• Why should investors fund it?

Developing 351-Regulated Cell and Gene Therapies (CGTs):

• Focus on nonclinical, quality, clinical, and regulatory factors

• Day 1: Pre-IND FDA meeting to align on expectations

Quality and Manufacturing:

• Quality Management Systems (QMS): documents policies, procedures, and controls for consistent quality

• cGMP: ensures controlled lab environments for safety and reproducibility

Manufacturing Run Includes:

• Materials/input

• Expansion process/output

• System, project, people, machine

• Upstream and downstream processes

Career Paths in Regulated Environments:

• Chemistry, manufacturing, and controls (CMC)

• Cell characterization

• Potency assay development

• In-process controls

• Data mining and informatics

Conclusions/action items:

Understanding regulatory pathways is just as important as technical design

• Knowing FDA classifications (351 vs 361, IND vs IDE, etc.) helps move a product from concept to clinic

• Mastering this knowledge increases value and leadership potential in biotech and biomedical companies

11/7/25 - Tong's Lecture

Title: Why healthcare needs more engineers?

Date: 11/7

Content by: Kenneth Sun

Present: Team

Goals: Learn more about healthcare and Kristin Myers story and career

Content:

Foundation: - 4 or 5 internships - Medtronic, Harvard MBA, Venture capitalist, Arboretum Ventures

Climb Growth Curve - Aetna - Decided to take on a challenging role = big opportunity = lead 100s of people (chief of staff of CEO or kinda like business residency

Chase difficulty - but with intention for impact

Fee for service model for hospitals

-

Conclusions/action items:

11/12/25 - IRB

KENNETH SUN - Nov 12, 2025, 2:07 PM CST

Title: Institional Review Board

Date: 11/12/25

Content by: Kenneth Sun

Present: Kenneth Sun

Goals: Learn more about IRB regulations and rules

Content:

- Belmont Report
    - Respect for persons autonomy
    - Justice for participants
- Common Rule Criteria
    - Risks, Benefits, Ratio
    - Equitable selection of subjects
    - Informed Consent
        - Participants need to make a informed choice on if they want to participate.
        - If not you are breaking ethics
        - Review of medical records from 2001 to 2015 - how do you get consent? This data could be valuable
            - Get waiver of informed consent
    - Privacy and confidentiality
        - Privacy - protecting person
        - Confidentiality - protect data
- You can get data from survey or from medical records
    - collection of bodily materials
- Some things not considered research
    - can't be performed systematically
    - not intended to be generalizable
    - quality of improvement projects
    - Self certification tool

Conclusions/action items:
IRB is super important and is a consideration that isn't thought about during most research since people don't usally work with hujna subjets.

11/19/25 - Industry Product Development

Title: Industry Product Development

Date: 11/19/25

Content by: Kenneth Sun

Present: Kenneth Sun

Goals: Learn how industry goes through product development from ideation to testing.

Content:

In today's lecture, we heard from Dr. Russ Johnson, a PhD who has spent about 25 years developing medical devices, especially tools and systems used in the operating room. He walked us through how new product development (NPD) works in the medical device industry and emphasized that it's not like developing a regular consumer product. Everything is highly regulated, extremely expensive, very resource-heavy, and the competition is intense because getting to market faster can be worth millions of dollars. Even just running the required clinical studies can cost millions on their own.

Dr. Johnson explained that there are different "levels" of NPD projects. Some are smaller, like **line extensions** (adding new sizes or versions of an existing product) or **product improvements** (making something safer, easier to use, or more reliable). Others are bigger, like **new-to-company** products (something that already exists in the world, but is new for that company) and the most ambitious category, **new-to-world** products (truly novel devices that no one has brought to market before). As you move from line extension to new-to-world, the risk, cost, and uncertainty usually all increase.

He also went over the **stage-gate process**, which is a structured way companies manage NPD:

- **Stage 0: Ideation** – This is the big brainstorm phase. The goal is quantity, not perfection. You might come up with 100+ rough ideas based on unmet clinical needs, surgeon feedback, OR workflow issues, and technology trends.

- **Stage 1: Exploration** – Here, the list gets filtered down to maybe 8–10 more serious ideas. The team starts doing secondary research: market size, existing competitors, basic regulatory considerations, and whether the idea fits the company's strategy and capabilities.

- **Stage 2: Concept Development** – The surviving ideas are developed into clearer concepts, usually narrowing to about 3–5. At this point, there's more structured input from customers (like surgeons, nurses, hospital admins) and internal teams (engineering, marketing, regulatory). Rough prototypes, use-cases, and value propositions might be drafted here.

- **Stage 3: Design Development** – If an idea gets the green light, it moves into real engineering. Detailed design work, risk analysis, materials selection, human-factors considerations, and early testing all happen here. This is where it starts to look like an actual medical device instead of just a concept.

- **Stage 4: Design Confirmation** – In this phase, the team focuses on testing and verifying that the device does what it's supposed to do, safely and consistently. This includes verification/validation testing, design freeze, and preparing for regulatory submissions and manufacturing scale-up.

Conclusions/action items:
Overall, Dr. Johnson's main message was that medical device NPD is a structured, high-stakes process where speed, safety, regulations, and business strategy all have to be balanced carefully at every stage.

9/14/25 - Ski Jumping Research Methods

KENNETH SUN - Dec 09, 2025, 8:58 PM CST

Title: Progress in Ski Jumping Technology Based on Biomechanics Sport Research Methods

Date: 9/14/25

Content by: Kenneth Sun

Goals: Get an overview on what kind of tools can be used and how they can be used to analyze ski jumping

Search Term: ski jumping biomechanics

Citation: [1] Y. Li, L. Liu, L. Xing, J. Chai, and D. Sun, "Progress in Ski Jumping Technology Based on Biomechanical Sport Research Methods," *Applied Sciences*, vol. 14, no. 6, p. 2281, Jan. 2024, doi: 10.3390/app14062281.

Link: https://www.mdpi.com/2076-3417/14/6/2281

Content:

Motion Video Capture and Analysis

Purpose: This method is one of the most essential for kinematic analysis. It describes the athlete's body attitude, speed, centroid components and builds the centroid trajectory. It can also be used to estimate the aerodynamic forces acting on the athlete.

Key Findings: Researchers consistently agree that controlling angular momentum during take-off and quickly reaching a stable flight position are major factors for performance. Body attitude angle influences flight distance more than the ballistic path of the centroid.

Limitations: Creating a universal video capture setup for all ski jumping hills is difficult because mountain layouts vary. Accuracy can be affected by ski suits, background interference and differences in hardware and software across studies.

Advancements: New systems like Intel 3DAT and the CCTV Cheetah System use AI video processing to reconstruct 3D body posture with very high precision, reducing measurement error to below 5 mm.

Force Plate

Purpose: Force plates are used to study take-off technique and measure ground reaction forces during take-off and landing. Research mainly focuses on the take-off phase using force–time and force–velocity curves.

Key Findings: Wind tunnel tests show that wind conditions shorten take-off time, highlighting the importance of explosive power. Elite athletes generate greater force as they approach the take-off edge.

Limitations: Installing force plates on actual hills is extremely challenging. Accurate landing data is almost impossible because snow conditions make calibration unreliable. Simulated take-offs differ substantially from real jumps, limiting application.

Wearable Inertial Measurement and Sensor Equipment

Purpose: IMUs, which include gyroscopes and accelerometers, are strong tools for capturing human motion in natural environments. They allow estimation of joint angles and center of mass movement. GNSS units add trajectory data with about 0.05 m accuracy. This makes the method ideal for capturing kinematics and dynamics during actual field training.

Limitations: These devices cannot be worn during competition. Many calculations rely on extrapolation and therefore need validation. Consistency across sensor units is another concern.

Surface EMG Measurement

Purpose: Surface EMG is used to study the timing and coordination of muscle activity during the jump. Research often compares lower limb muscle activity across field conditions, simulation or in combination with force plates to build a full biomechanical picture.

Limitations: There is limited research from actual mountain training. Most studies are done in labs. EMG also cannot be used during competition. More work is needed to understand how EMG patterns relate to mechanical and kinematic data.

Wind Tunnel Measurement

Purpose: Wind tunnels are vital because aerodynamics strongly determine flight distance. The human-ski system is complex and cannot be expressed with simple formulas. Wind tunnels allow measurement of aerodynamic forces and help guide technique optimization.

Key Findings: Lift and drag forces can be measured directly in these tests. Body posture has a major effect on flight distance. Wind tunnels create a controlled environment for evaluating and improving technique.

Computer Simulation

Purpose: Simulation focuses on optimizing flight posture. It simplifies the athlete and skis into models and uses aerodynamic data plus Newtonian mechanics to simulate flight paths and determine optimal attitudes.

Key Findings: Simulations of the V position show an increase in lift–drag ratio and overall flight distance. Studies suggest optimal ranges for upper body bending angle and the angle between the body and skis.

Credibility and Limitations: Simulation is often more credible than experiments when studying how posture affects flight distance. However, the underlying theory must be sound, and the simplified model must realistically represent the actual jumping process.

Conclusions/action items:
Some of these applications can be used for our design matrix, especially the motion video capture analysis such as Opensim or Kinovea. Perhaps a combination of these tools can capture a robust diversity of data that can be compiled to produced a ski jumping training system that provides quantitative feedback for these athletes. Computer simulation could also be explored and a pre-existing model of ski jump flight could be utilized to further analyze the youth athletes form and jumps technique.

9/29/25 - Norwegian Ski Jumping Video Based Pose Estimation

KENNETH SUN - Dec 09, 2025, 8:53 PM CST

Title: Performance Analysis in Ski Jumping with a Differential Global Navigation Satellite System and Video-Based Pose Estimation

Date: 9/29/25

Content by: Kenneth Sun

Goals: Figure out the Physics FBD that the research shows and understand what each component means

Search Term: Sent by the client Dr.Azam

Citation: [1] O. Elfmark *et al.*, "Performance Analysis in Ski Jumping with a Differential Global Navigation Satellite System and Video-Based Pose Estimation," *Sensors*, vol. 21, no. 16, p. 5318, Jan. 2021, doi: 10.3390/s21165318.

Link: https://www.mdpi.com/1424-8220/21/16/5318

Content:

Methods of Data Collection:

differential Global Navigation Satellite System (dGNSS) and markerless video-based pose estimation system (PosEst).

PosEst dramatically decreases post processing of video analysis and may improve sample size and generalizability of ski jumping studies.

Goals/Aims of study:

1. Agreement between both methods

- Good agreement from 5m after the take-off. dGNSS uncertainty (+-0.05m)

2. Showcase type of performance analysis allowed by both methods

- Methods are suitable to track kinematic and kinetic characteristics of ski jumper

PosEst - take-off and early flight phase

dGNSS - in-run and flight phase

Validity (external + internal):

1. No instrumentation that hampers performance of athlete

2. Performance level of subjects should represent population that is studied and lots of subjects for generalization

3. equipment measuring data needs sufficient accuracy and precision despite outdoor environment

Video Based PosEst Method:

1. Technology and Function: It is a markerless video-based pose estimation system that relies on a state-of-the-art convolutional neural network (ConvNet) for high-precision pose estimation.

2. Purpose in Ski Jumping: The PosEst system is used to describe the kinematics and kinetics of the take-off and early flight phase using a body segment model, covering the area analyzed from −5 m before the jump edge to 20 m after. It provides an accurate way to assess the Center of Mass (CoM) motion during the take-off phase, where other measurement systems (like dGNSS head-mounted antennae) are less accurate representations of the CoM.

Data Extraction: The system estimates the x and y coordinates of 16 body parts (landmarks), including the head top, shoulders, elbows, wrists, knees, and ankles. These landmarks are used to calculate performance parameters such as the CoM trajectory, resultant and component velocities, calculated aerodynamic forces (Drag and Lift), the lift-to-drag ratio, knee angle, hip angle, and the body angle of attack.

Conclusions/action items:

This paper helped me actually see how the physics of a ski jump are captured in the real world. dGNSS handles the overall motion once the jumper is in the air, and the PosEst system fills in the tricky take-off zone by tracking the true center of mass and joint angles without putting

anything on the athlete. When you combine the two, you get a clear picture of the forces acting on the jumper such as gravity, lift, drag and the take-off impulse, and how those forces change from the in-run to early flight. For our project, the main takeaway is that this mix of pose estimation and accurate trajectory tracking is basically required if we want meaningful performance data from outdoor jumps.

9/29/25 - KScore Explained (Performance Metric)

KENNETH SUN - Oct 14, 2025, 12:31 PM CDT

Title: Ski jump scoring mechanism: K score and Style points

Date: 10/14/25

Content by: Kenneth

Goals: Kenneth

Search Term: Ski jump K score

Citation: "Olympic Ski Jumping Scoring: Distance Points, Style Marks and Wind Compensation Explained | NBC Olympics." Accessed: Oct. 02, 2025. [Online]. Available: https://www.nbcolympics.com/news/ski-jumping-101-scoring

Link: **https://www.nbcolympics.com/news/ski-jumping-101-scoring**

Content:

- The K-point is the target distance on the hill, kind of like the "par" in golf.

- It marks the spot where the hill starts to flatten out.

- If you land right at the K-point, you get 60 points (the baseline).

- For every meter beyond the K-point, you add extra points.

- For every meter short, you lose points.

- The number of points per meter depends on the hill size:

    - Normal hill: ±2.0 points per meter

    - Large hill: ±1.8 points per meter

- Distance is only part of the total — judges also score style, and the system adjusts for wind and gate changes too.

- Final jump score = distance points + style points ± wind/gate compensation.

Conclusions/action items:

This scoring system is for a professional setting so it may not fully apply to the Blackhawk Ski Club scoring. Update* - after talking to Coach Finn we were able to figure out the scoring of the Blackhawk ski club which consist of three judges scoring based on form and style: the max score is 20 and points are deducted for each error. This type of scoring is quite qualitative but should be good enough to tag each jump with a relative score.

10/2/25 - Ski Jumping 101

KENNETH SUN - Nov 20, 2025, 6:41 PM CST

Title: Ski Jumping Basics and Rules

Date: 11/20/25

Content by: Kenneth Sun

Goals: Learn more about the basic foundation of Ski Jumping in terms of rules, culture, and more

Search Term: Ski jumping basic rules

Citation: Ski Jumping

Link: **https://usaskijumping.com/ski-jumping-101/**

Content:

- Ski jumping is a sport where skiers go down a takeoff ramp and jump while attempting to land as far down a hill as possible.
  - The method of scoring as mentioned in the "K-score explained note" is based off distance and style points
- Ski jumping is a safe non-contact sport, where beginner ski jumpers begin on small hills with alpine skis and work their way up to larger hills.
- There are 4 main phases of the ski jump
  - In-run: This is the 1st phase and the position skiers assume during the beginning where they aim to streamline their body to prevent drag as they go down the hill
  - Takeoff: This phase is when the skier changes body position and jump/raise their center of gravity as high as possible without creating more air resistance.
    - This means having the upper body be parallel to the slope and knees that are more forward to achieve more optimal shin angles for the best takeoff
  - Flight: This phase focuses on having the jumper's body parallel to the skis to enhance lift and is when jumpers spread their skis like a V to increase SA for longer air time
    - Usually in air
  - Finally

Conclusions/action items:

Kinovea - Angles and Speed (Show and Tell)

KENNETH SUN - Dec 09, 2025, 9:32 PM CST

Title: Kinovea - Body angles and Speed Determination for Show and Tell

Date: 10/30/25

Content by: Kenneth Sun

Present: Kenneth Sun

Goals: Record how I did both the angles and the speed + any other useful procedures

Content:

Video Setup
I filmed with the camera perpendicular to the motion so the jumper stayed in a true 2D plane. I used a fixed tripod, checked the frame rate (ideally 60 fps or higher), and put a calibration object of known length in the same plane as the jumper. (measuring stick on ski jump hill zip tie to zip tie 13 in)

Importing into Kinovea
I opened the video in Kinovea, confirmed the fps, and trimmed the clip to only the part I wanted to analyze (in-run, take-off, early flight).

Calibration
I used the calibration tool to draw a line over the known object and entered its real length in meters. I double-checked the scale by measuring another known distance. This ensures all angle and speed calculations have correct real-world units.
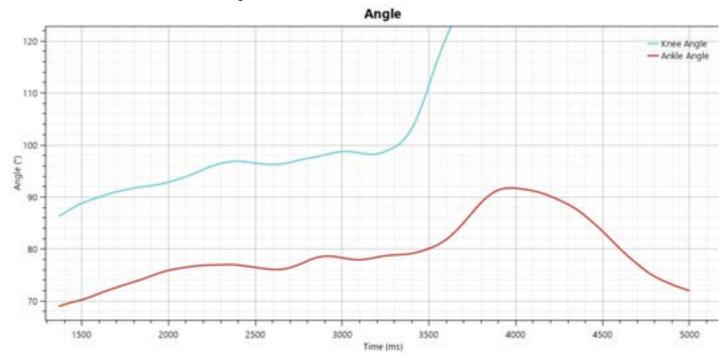
Setting Up Body Angles
I used the angle tool to define knee, hip, trunk and body-attack angles. I consistently placed the points on the same joints each time (ankle, knee, hip, shoulder). I labeled each angle overlay for clarity - Knee angle and Ankle angle.

Tracking Angles Over Time
I moved through the video frame-by-frame and repositioned the joint markers at each frame. Kinovea updated the angle values automatically. After finishing the take-off and early flight phase, I used Kinovea's auto graphing feature to graph the angle over time for use in show and tell.

Conclusions/action items:

 Got the angle between the back of the leg and the calf or the knee angle and was able to graph the curve out. Due to the color of the pixels and their similarity the auto tracking feature of the markers kept drifting off of the angle anchor points requiring frame by frame adjustments. Need to include white markers on ski athletes the next time we go out to

the ski hill to ensure better auto tracking.

📦 Kinovea CSV to Graph (Matlab Code)

Title: Kinovea CSV data graphing code

Date: 12/3/25

Content by: Kenneth Sun

Present: Kenneth Sun

Goals: Convert Kinovea CSV of Ski Jumper 1 and 2 knee and ankle angles into graphical representation for analysis

Content:

```
%%% Kinovea Data Graph of USA and Green/Black Ski Jumpers

close all;   % closes all open figures each time you run

clear all;

% Read in data for both ski jumpers

usa28 = readtable("/Users/ks14/Library/Mobile Documents/com~apple~CloudDocs/UW 25:26/BME design/usa28.knee.ankle.data.csv");

usa30 = readtable("/Users/ks14/Library/Mobile Documents/com~apple~CloudDocs/UW 25:26/BME design/usa30.ankle.knee.data.csv");

usa36 = readtable("/Users/ks14/Library/Mobile Documents/com~apple~CloudDocs/UW 25:26/BME design/usa36.knee.angle.data.csv");

usa40 = readtable("/Users/ks14/Library/Mobile Documents/com~apple~CloudDocs/UW 25:26/BME design/usa40.knee.ankle.data.csv");

bg29 = readtable("/Users/ks14/Library/Mobile Documents/com~apple~CloudDocs/UW 25:26/BME design/greenblack29.knee.ankle.data.csv");

bg33 = readtable("/Users/ks14/Library/Mobile Documents/com~apple~CloudDocs/UW 25:26/BME design/greenblack33.knee.angle.data.csv");

bg37 = readtable("/Users/ks14/Library/Mobile Documents/com~apple~CloudDocs/UW 25:26/BME design/greenblack37.knee.angle.data.csv");

bg41 = readtable("/Users/ks14/Library/Mobile Documents/com~apple~CloudDocs/UW 25:26/BME design/greenblack41.knee.ankle.data.csv");


%%% USA Jumper (converted to vectors)

usa28_time      = usa28{:, "Time_ms_"};
```

```matlab
usa28_knee_angle  = usa28{:, "KneeAngle"};

usa28_ankle_angle = usa28{:, "AnkleAngle"};


usa30_time        = usa30{:, "Time_ms_"};

usa30_knee_angle  = usa30{:, "KneeAngle"};

usa30_ankle_angle = usa30{:, "AnkleAngle"};


usa36_time        = usa36{:, "Time_ms_"};

usa36_knee_angle  = usa36{:, "KneeAngle"};

usa36_ankle_angle = usa36{:, "AnkleAngle"};


usa40_time        = usa40{:, "Time_ms_"};

usa40_knee_angle  = usa40{:, "KneeAngle"};

usa40_ankle_angle = usa40{:, "AnkleAngle"};


%% Green/Black Jumper (converted to vectors)

bg29_time         = bg29{:, "Time_ms_"};

bg29_knee_angle   = bg29{:, "KneeAngle"};

bg29_ankle_angle  = bg29{:, "AnkleAngle"};


bg33_time         = bg33{:, "Time_ms_"};

bg33_knee_angle   = bg33{:, "KneeAngle"};

bg33_ankle_angle  = bg33{:, "AnkleAngle"};


bg37_time         = bg37{:, "Time_ms_"};

bg37_knee_angle   = bg37{:, "KneeAngle"};

bg37_ankle_angle  = bg37{:, "AnkleAngle"};
```

```matlab
bg41_time       = bg41{:, "Time_ms_"};

bg41_knee_angle  = bg41{:, "KneeAngle"};

bg41_ankle_angle = bg41{:, "AnkleAngle"};


%% Convert USA time vectors to seconds

usa28_time = usa28_time / 1000;

usa30_time = usa30_time / 1000;

usa36_time = usa36_time / 1000;

usa40_time = usa40_time / 1000;


%% Convert Green/Black time vectors to seconds

bg29_time = bg29_time / 1000;

bg33_time = bg33_time / 1000;

bg37_time = bg37_time / 1000;

bg41_time = bg41_time / 1000;


%% Zero the time values for each jump

usa28_time = usa28_time - usa28_time(1);

usa30_time = usa30_time - usa30_time(1);

usa36_time = usa36_time - usa36_time(1);

usa40_time = usa40_time - usa40_time(1);


bg29_time  = bg29_time  - bg29_time(1);

bg33_time  = bg33_time  - bg33_time(1);

bg37_time  = bg37_time  - bg37_time(1);

bg41_time  = bg41_time  - bg41_time(1);


%% ---- USA Knee Angle Plot ----

figure(1)
```

```matlab
subplot(2,1,1);     % 2 rows, 1 column, top plot

hold on

plot(usa28_time, usa28_knee_angle);

plot(usa30_time, usa30_knee_angle);

plot(usa36_time, usa36_knee_angle);

plot(usa40_time, usa40_knee_angle);


title("Ski Jumper 1: Knee Angle vs Time");

xlabel("Time (s)");

ylabel("Knee Angle (Deg)");

grid on

legend("USA28", "USA30", "USA36", "USA40");

hold off


%% ---- USA Ankle Angle Plot ----

subplot(2,1,2);     % 2 rows, 1 column, bottom plot

hold on

plot(usa28_time, usa28_ankle_angle);

plot(usa30_time, usa30_ankle_angle);

plot(usa36_time, usa36_ankle_angle);

plot(usa40_time, usa40_ankle_angle);


title("Ski Jumper 1: Ankle Angle vs Time");

xlabel("Time (s)");

ylabel("Ankle Angle (Deg)");

grid on

legend("USA28", "USA30", "USA36", "USA40");

hold off

%% ---- Green/Black Knee Angle Plot ----
```
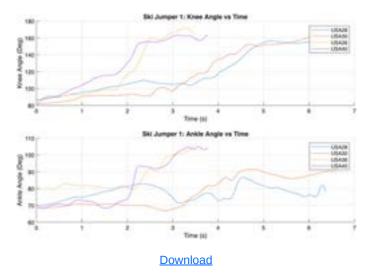
```matlab
figure(2)   % New figure for Green/Black group

subplot(2,1,1);     % Top plot

hold on

plot(bg29_time, bg29_knee_angle);

plot(bg33_time, bg33_knee_angle);

plot(bg37_time, bg37_knee_angle);

plot(bg41_time, bg41_knee_angle);

title("Ski Jumper 2: Knee Angle vs Time");

xlabel("Time (s)");

ylabel("Knee Angle (Deg)");

grid on

legend("GB29", "GB33", "GB37","GB41");

hold off

%%% ---- Green/Black Ankle Angle Plot ----

subplot(2,1,2);     % Bottom plot

hold on

plot(bg29_time, bg29_ankle_angle);

plot(bg33_time, bg33_ankle_angle);

plot(bg37_time, bg37_ankle_angle);

plot(bg41_time, bg41_ankle_angle);

title("Ski Jumper 2: Knee Angle vs Time");

xlabel("Time (s)");

ylabel("Ankle Angle (Deg)");

grid on

legend("GB29", "GB33", "GB37","GB41");

hold off
```

Conclusions/action items:

 Graphing the angles for 4 trials or jumps for 2 ski jumpers during the ski jump jamboree training day. Serves as a proof of concept of what can be done with 2d video motion analysis and give insight to coach feedback that could be used.
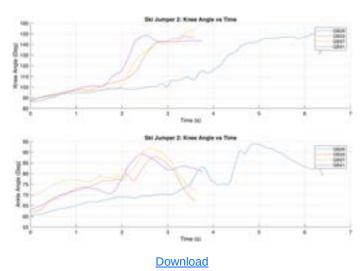
For example, for jumper1 two of his jumps increase very fast which indicate a straight up triple extension which is not ideal. Or having very good consistent in run form through similar angles when the curve starts/y-intercept.

KENNETH SUN - Dec 09, 2025, 9:46 PM CST

[Download](#)

jumper1.png (82.8 kB)

KENNETH SUN - Dec 09, 2025, 9:46 PM CST

[Download](#)

ski_jumper2graphs.png (98.9 kB)

9/29/25 - OpenSim BME 315 Lab Manual

KENNETH SUN - Sep 29, 2025, 11:18 AM CDT

Title: BME 315 Biomechanics Lab Manual

Date: 9/29/25

Content by: Kenneth Sun

Goals: Get a basic overview on how to use OpenSim from the lab manual acquired from Dr.Willie

Search Term: Emailed Dr.Willie for it

Citation: [1] "Lab 3 - Markerless Mocap Lab Manual BME Design Reference," Google Docs. Accessed: Sept. 29, 2025. [Online]. Available: https://docs.google.com/document/u/1/d/1fD2dK4SosQQtEicFJJbK-EyDGsJMju3Dg5maKgtgDEo/edit?tab=t.0&usp=embed_facebook

Link: https://docs.google.com/document/d/1fD2dK4SosQQtEicFJJbK-EyDGsJMju3Dg5maKgtgDEo/edit?tab=t.0

Content:

- Passive Markers
    - Track reflective markers that show up as bright dots on camera views.
- Active Markers
    - IR diodes that are tracked via IR-sensitive cameras
- Markerless
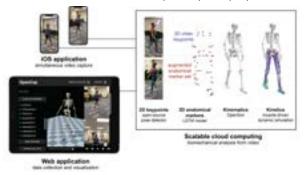   - Uses numerical algorithms to recognize shape of person in a camera view via predefined models.

Each type of MoCap maker relies on triangulation to determine the 3D position of the object. This requires at least two cameras to record and calculate the marker position in 3D.

OpenCap/OpenSim: Leverages pose estimation algorithms to identify body landmarks from 2D videos; deep learning and biomechanics models to estimate 3D kinematics (motion); and physics-based simulations to estimate muscle activations and musculoskeletal dynamics.
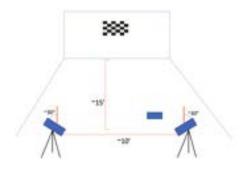
KENNETH SUN - Dec 09, 2025, 9:00 PM CST

Content (Cont.):

-
- Smartphone App, Web App, Cloud Computing
- Collect data:
    - 2 IOS devices need to pair and web application allows for simultaneous recording.
    - Videos are time synched

OpenCap Setup Key points:

- Set up requires checkered calibration square

Data Collection Key points:

Log in to OpenCap and scan both data collection devices via QR to sync.

Subject should be facing general direction of the cameras for best results

Keep videos short as possible - take long time to process!

Green dot means file is processed and ready for analysis in OpenSim

Data Processing Key points:

Zip folder:

MarkerData and OpenSimData files most important

MakerData includes x,y,z coordinates for each "marker"

Conclusion/Action Items:

We will test this open cap at the BME teaching labs first but we need to get out to the hills and find a place to set up outside. This might be tricky due to the optimized conditions required for OpenCap to work. Next steps is to try the software out in both indoor and outdoor settings.

9/29/25 - OpenCap Best Practices (Setup, Data Collection, Etc)

Title: Open Cap Best Practices

Date: 9/29/25

Content by: Kenneth Sun

Goals: Figure out the most optimized way to use OpenCap to collect the best data possible.

Search Term: OpenCap (embedded link once you log in for first time)

Citation: [1] "Best practices." Accessed: Sept. 29, 2025. [Online]. Available: https://www.opencap.ai/best-practices

Link: **https://www.opencap.ai/best-practices**

Content:

Overall:

Stable internet connection, do not touch cameras after calibrated, checkerboard is only used for calibration - you can remove after your done with that

Camera Setup:

Use Rear facing camera, position camera to avoid segment occlusions, avoid background people, avoid having participant exit and re-enter the capture volume.

https://www.youtube.com/watch?time_continue=47&v=LPHeq7bxP38&embeds_widget_referrer=https%3A%2F%2Fwww.opencap.ai%2F&embeds_referring_euri=https%3A%2F%2Fcdn.embedly.com%2F&embeds_referrin(
(Capture Volume, how to fit particpant with two cameras)

2 cameras need to see every body segment at all times during movement.

2 camera segment - 30 to 45 deg off the line facing the participant is best, pure sagittal view should be avoided

Camera Calibration:

Record in well-lit environment, no direct sun on checkerboard if outside

Checkerboard needs to be A4 with squares at least 35mm and white border all sides

Checkerboard should be within less than 5m from the cameras, should be perpendicular to ground with long edge parallel to ground

https://www.youtube.com/watch?v=T6TkFLEfQ0Y (calibration and setup)

Data Collection:

Tight clothing that contrasts with simple background and shoes that contrast with floor is helpful

Start recording at least 1s before participant begins movement

Press new session same setup if you want to add another participant but with same setup

https://www.youtube.com/watch?time_continue=13&v=h4jaSZwcrm8&embeds_widget_referrer=https%3A%2F%2Fwww.opencap.ai%2F&embeds_referring_euri=https%3A%2F%2Fcdn.embedly.com%2F&embeds_referring

Conclusions/action items:

It will be vital to capture this data outdoors using these tips and tricks as a reference. We also need to acquire 2 different phone style tripods so that we can setup cameras properly.

9/29/25 - Tom Brady Ball Spin Study (Physics Model Research Desgin Idea)

KENNETH SUN - Sep 29, 2025, 12:39 PM CDT

Title: Tom Brady Physics Model Research Design Comparison Idea

Date: 9/29/25

Content by: Kenneth Sun

Present: Kenneth Sun

Goals: Learn how Veritasium used a simplified physics model to act as a standard for his research. Try to see if we can incorporate this into our ski jump study.

Content:

https://www.youtube.com/watch?v=J3i3F2e4IYs

Why can't even the GOAT football quarterback throw a perfect spiral?

This video uses concepts of drag, gyroscopic procession, and lift to explain why the football is not able to go in a straight line and why when you spin a ball in a parabolic path, the nose of the ball tends to wobble and turn over pointing back down.

What I noticed in this video is that they used physics FBD animation to show one type of physics phenomenon like procession to explain one physical phenomenon like the wobble + turnover.

I'm not sure how well we can break down each part of a ski jump into one physics explanation but maybe we can use FBD to explain how decreasing trunk angle and getting more flat can decrease the force of the drag?

Conclusions/action items:

I need to continue to do research on the existing models for ski jumping including the FBD and even path trajectory as well. Then I can discuss with my team on what kinds of physics models we want to explain a certain physical phenomenon of the ski jumper.

10/1/25 - Research Study Design w/ Dr.Sun

KENNETH SUN - Oct 02, 2025, 6:29 PM CDT

Title: Research Study Design

Date: 10/1/25

Content by: Kenneth Sun

Present: Kenneth Sun

Goals: Figure out what our research design is and how to apply Dr.Bartels advice

Content:

- Get as many types of data - Accelerometer, Force Plate, Angles, etc
  - Get as many data points as possible
- Takeoff Phase
  - arm angle, head position, leg angel, initial velocity, ground reaction force, etc
- Initial Flight
  - gyroscopic rotation, more body angles, and ski angles
- Metric Choosing Reasoning - look at old papers and see why they chose their metrics
- Use Machine learning

Conclusions/action items:

1. Get the data: figure out which metrics to measure (online papers reference)
   1. Figure out how to do this. What sensors do we need? What kinds of Imaging technology (motion cap, 2d video analysis, other)
2. Once you get data, how do you extrapolate correlations to improved K scores
   1. Regression analysis
      1. You can add multiple inputs (different metrics)
      2. K score is our output
3. Error analysis
4. Based on Correlation (R^2)
   1. We can use this to make proposals for some logistical mechanisms to help give advice to coaches. Logic it out with physics and Math.

Electronics Case Design Brainstorming

Title: Brainstorm initial design ideas for the case that will hold all the electronics

Date: 12/9/25

Content by: Kenneth Sun

Present: Kenneth Sun, Presely, and Matthew

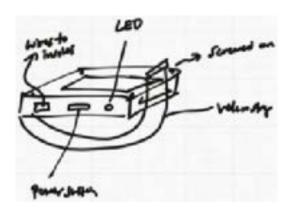**Goals:** Get initial discussion on the form factor and other considerations.

Content:

- 3D print or Laser cut design - PLA or some other Plastic Material
- Matthew to do the CAD drawing for this case
- Must have LED indicator light that can be drilled out later
- Must have cut out for on/off button and wires leading to force plate insoles
- Velcro straps or Velcro Table on both surfaces. One piece of velcro on the back of the boot and the other on the case itself
- Could drill out or mill rectangular opening for the strap - Design a oval hole that acts as two arm hooks on either side of the case
- Chamfer the end CAD design

Conclusions/action items:

We ended up having issues with the sizing of the first 3d print which was mainly an issue with the depth of the main compartment which was too shallow for both the battery and microcontroller. We increased the depth and the witdth a bit as well. Also increased the button and wire openings and had to resize the arm hooks for the strap to be the same size.
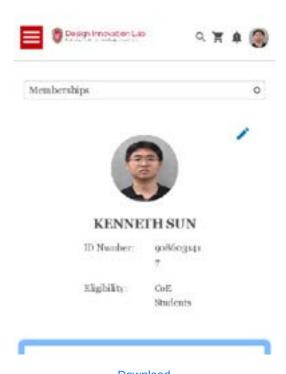
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Drawing.pdf (1.22 MB)

Training Memberships

KENNETH SUN - Feb 25, 2025, 11:42 AM CST

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Profile_-_Design_Innovation_Lab_-_UW_Madison.pdf (393 kB)

KENNETH SUN - Oct 30, 2025, 10:11 AM CDT

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compliance.research.wisc.edu_TILT_Details_9038178.pdf (76.4 kB)

9/18/25 - Product Design Specification

KENNETH SUN - Dec 09, 2025, 9:51 PM CST

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Product_Design_Specification.pdf (277 kB)
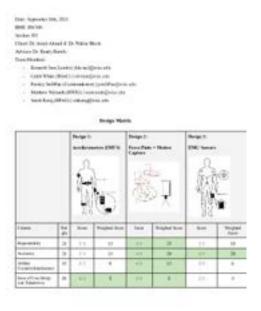
10/3/25 - Preliminary Oral Presentation

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F25_Preliminary_Presentation.pdf (2.63 MB)

10/8/25 - Ski Jump Design Matrix

KENNETH SUN - Dec 09, 2025, 9:53 PM CST

Download

BME_200_300_Ski_Jump__Design_Matrix.pdf (431 kB)

10/8/25 - Preliminary Report

KENNETH SUN - Dec 09, 2025, 9:53 PM CST

[Download](#)

Preliminary_Report.pdf (1.93 MB)

12/5/25 - Poster Presentation

KENNETH SUN - Dec 09, 2025, 9:54 PM CST

[Download](#)

Final_Presentation_current_.pdf (1.74 MB)

12/10/25 - Final Report

2014/11/03-Entry guidelines

John Puccinelli - Sep 05, 2016, 1:18 PM CDT

Use this as a guide for every entry

- Every text entry of your notebook should have the **bold titles** below.
- Every page/entry should be **named starting with the date** of the entry's first creation/activity, subsequent material from future dates can be added later.

You can create a copy of the blank template by first opening the desired folder, clicking on "New", selecting "Copy Existing Page...", and then select "2014/11/03-Template")

Title: Descriptive title (i.e. Client Meeting)

Date: 9/5/2016

Content by: The one person who wrote the content

Present: Names of those present if more than just you (not necessary for individual work)

Goals: Establish clear goals for all text entries (meetings, individual work, etc.).

Content:

Contains clear and organized notes (also includes any references used)

Conclusions/action items:

Recap only the most significant findings and/or action items resulting from the entry.

2014/11/03-Template

CALEB WHITE - Sep 08, 2025, 8:45 PM CDT

Title:

Date:

Content by:

Present:

Goals:

Content:

Conclusions/action items:

CALEB WHITE - Sep 08, 2025, 8:45 PM CDT

Research Template

CALEB WHITE - Sep 08, 2025, 8:47 PM CDT

Title:

Date:

Content by:

Goals:

Search Term:

Citation:

Link:

Content:

Conclusions/action items: