MSE 420 Project Proposal
Bionic Knee Actuator Device

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1. Background

The adventurous activity of backcountry hiking has become an extrememly popular outdoor excursion in British Columbia. With the latest developments in a vast network of interconnected backcountry trails, growing popularity and demand, as well as advancements in environment preservation through limitations of campers at any given time by BC Parks, people of all ages seek to explore BC's many beautiful destinations. Hence the nickname, Beautiful British Columbia.

1.1. Motivation

Hikes and trails throughout BC's backcountry vary in length, terrain, and elevation gain. Most hikes begin with a long ascent, to a lake or peak, or even a waterfall. More often than not, these same trails require a hike out after spending a night or two at the destination. This hike requires a descent through the treacherous terrain that has caused many knee injuries in the past. The descent is frequently the cause of injury for most hikers, as one's legs are tired from trek of the days before. However, the intense incline of the ascent also induces the most fatigue throughout the entire trek. Nonetheless, there are many aspects of a trek through the backcountry that revolve around the strength of one's legs and the knee joint. A means of reinforcing this joint would most defintiely benefit all levels of hikers.

2. Proposed Idea

Our group is proposing to study the biomechanics of the knee joint during a hike and develop means of reinforcement to support this joint during fatigue-inducing or injury-susceptible conditions; an exoskeleton. As such, our key resources for the study of the knee joint will come from previous biomechanical research papers as well as case studies conducted on the knee joint. The next component of our project — the design of the

exoskeleton — will be developed after sufficient information has been gathered from the literature review.

To begin the design stage, we need to determine the forces at play in the knee joint during a full gait cycle. Once those forces are known, we can establish regions of the gait that may lead to higher stress on the joints or establish conditions that lead to injury. Using this information, the team will have the necessary data to design a joint reinforcing system that can actively dampen the striking force on the knee joint and provide actuation during the gait cycle that requires the most work from the agonist-muscle group. A general idea of what the team has in mind is illustrated on ~~Figure 1 in the Appendix~~.

Project deliverables: Motion study of the knee joint during various gait conditions, study of active forces produced in the knee joint, and exoskeleton design for the knee joint.

2.1. Potential Hiking Applications

Overall, there are many areas of applications for this solution. The list includes, but is not limited to:

- High-torque actuated extension of the knee joint during steep inclines to reduce fatigue, essentially giving the hiker a 'boost.'
- Rythmic actuation to follow a velocity profile of the knee joint during flat walking of long duration.
- Reverse high-torque battery 'regenerative braking' during steep decline to dampen the jarring of large steps and thus potential damage to knee cartilage.

3. Proposed Analysis Methods / Tools Required

We will use Open Track, Logger Pro, or Matlab's Image Processing Toolbox for the planar motion capture (manual or automatic) of a group member's hip, knee, and ankle joints (i.e., joint markers) for different gaits — at least walking at an incline. (If we record multiple gaits, they will be compared.) We will then be using Matlab for our kinematic and dynamic analyses of the angular velocity profile between the femur and tibula; at the knee. These constitute the *data collection and analysis* project requirements, and allow us to select the motor in what would be a closed-loop velocity control system. This leads us toward the anthropometrically- and structurally-oriented design, 3D modeling, and possible FEA of the knee reinforcement, all of which would be done in SolidWorks. This constitutes the *design component* of the project.

Limitations: We are not building the knee reinforcement, implementing the controller, or including any power electronics.