To: Engineering Design Team
From: Tufts Alumni Class of 2023
Re: Automating Kindlevan Cafe

I graduated from Tufts with a degree in Mechanical Engineering this past year. I am contacting you regarding my plans to automate the dining experience at Kindlevan Cafe on the Tufts Medford/Somerville campus.

Kindlevan Cafe, located in the Science and Engineering Complex at Tufts University, is frequently faced with long lines. The cafe often cannot meet the demands of the student population, especially at popular meal times or when classes get out. The time required to prepare drinks and check out customers results in long wait-times and lines that typically wrap around the building. In order to lessen the staff demands and ensure faster service, we would like to automate the drink-making process using robots that measure and mix ingredients.

I am creating a startup to address this problem with robots that handle each step of the drink-making process. Customers can place orders on their mobile devices. On a conveyor belt, designated robots will measure out and dispense different ingredients into a cup. The appropriate ingredients will then either be mixed or blended. A worker can then serve the drink and the robot will clean the cup. After automating Kindlevan, I plan to scale my company to cafes around the country.

I would love to recruit more Tufts students to work on this project! I have attached a specification sheet containing information about components used in our robots and other useful information. Based on your analysis, please write a memo about whether or not we should pursue this startup.

Sincerely,
Tufts Alumni

You may find it useful to estimate the energy required to produce one robot. Figures 1 and 2 show an existing cooking robot setup that we would like to adapt for drink-making.

Figure 1. *Cooking robots assembly line*

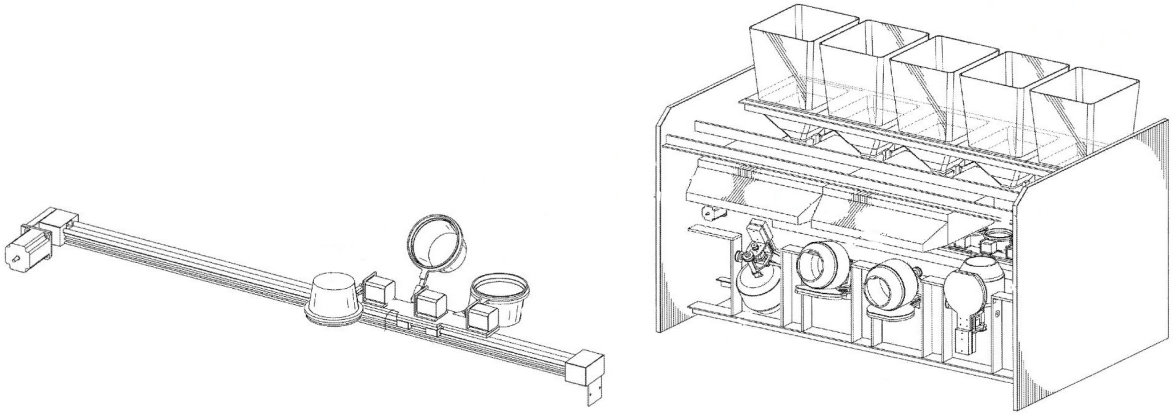

Figure 2. *Robot schematic with conveyor belt and ingredient dispensers*

Material	Mass
Stainless steel	2 kg
Polycarbonate plastic	1.3 kg
PVC pipes	0.5 kg
Teflon (PTFE) coating	0.03 kg

Table 1. *Robot Material Composition by Mass*

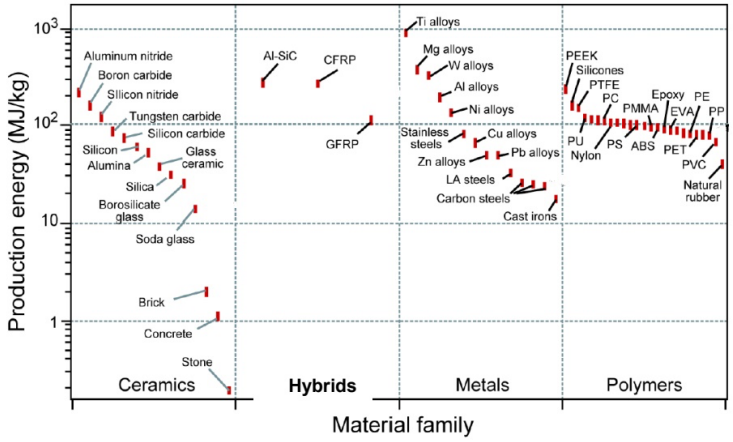

Figure 3. *Embodied Energy by Mass Graph*

Reference:
4.18 MJ = 1,000 food calories. (MJ = MegaJoule = 10^6 Joules)

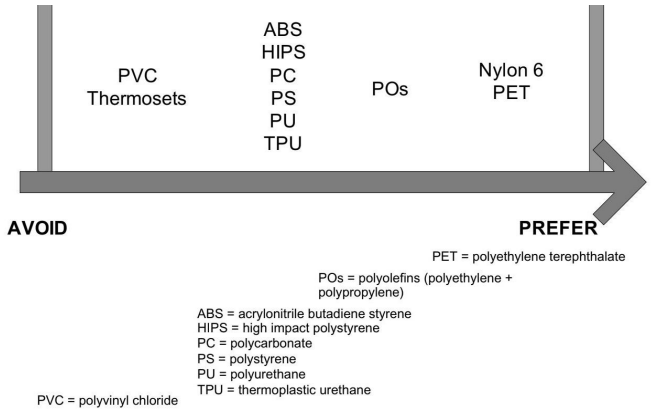

Figure 4. *Recyclability of Plastics Chart*

Below is a table of power ratings of appliances whose motors will be similar to those used for each respective step in the drink-making process and an estimate for their time in use. Assume there are two main types of drinks at Kindlevan: a stirred coffee drink and a blended smoothie drink. You may find it useful to estimate the amount of energy the robot uses to make the two types of drinks.

Reminder:
1 Watt = 1 Joule/second. For reference, 1 kJ of energy can power a 100 W lamp for 10 seconds.

Appliance	Power Rating	Time in Use
Grocery store conveyor belt	20,000 W	30 seconds
Blender	1300 W	30 seconds
Hand mixer	250 W	15 seconds
Dishwasher pump	1800 W	30 seconds
Ingredient dispenser	250 W	3 seconds

Table 2. *Power Ratings and Time in Use of Appliances*

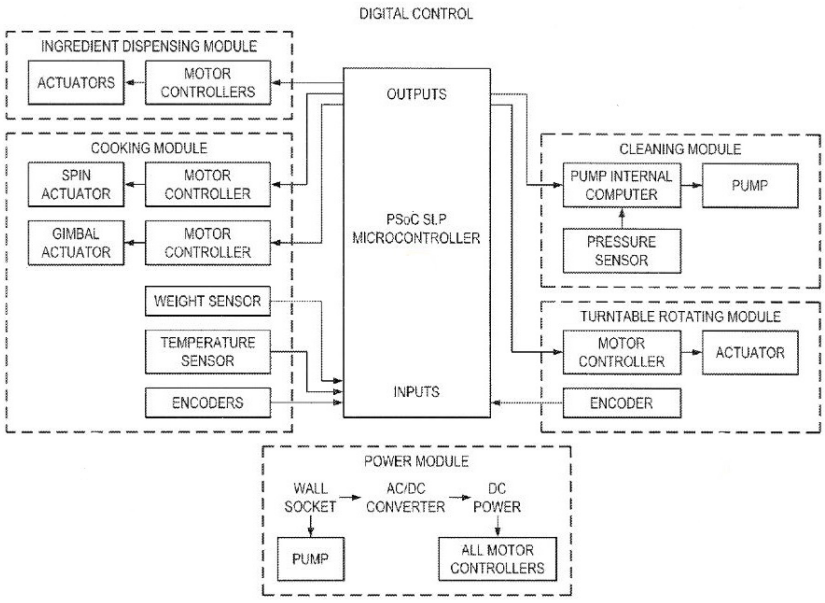

Figure 5. *Electronics Function Structure Diagram for Cooking Robot*