I. Abstract

An inventor in Santa Barbara, California has come up with a design for a new type of football helmet which he feels may help reduce the risk of concussions in football players. His hope is that his design will help to diffuse the impact energy away from the sight of impact and spread it out along the entire helmet. In order for this design to be proved out, it must be tested. We will be carrying out both physical testing and computer modeling to help determine whether this helmet design has merit.

As part of the helmet testing, a testing fixture has to be created which will allow testing per ASTM and NOCSAE (National Operating Committee on Standard for Athletic Equipment) standards. This test consists of a helmet on an instrumented headform being guided into an impact surface to measure the impact attenuation and determine the risk of concussion from a standard impact.

This testing fixture is the main purpose of this project. With the public's eye on the dangers of football and other impact sports, with movies like Concussion with Will Smith, the area of helmet study and human impact biomechanics are prominent fields with a lot of research and new designs being made. At the conclusion of this project, Cal Poly will be among one of the few universities able to do helmet research. In addition, the machine is able to be reconfigured quickly to any kind of human impact biomechanics, a very large field of study.

II. Project Description

The end goal of this project is to have all the equipment in order to carry out human impact biomechanics research, specifically helmet research, and to determine if an inventor from Santa Barbara, California's design for a new helmet will help reduce the risk of concussion in athletes. The inventor's design can theoretically disperse the energy around the athletes head instead of all the force of the impact being directed into the head.

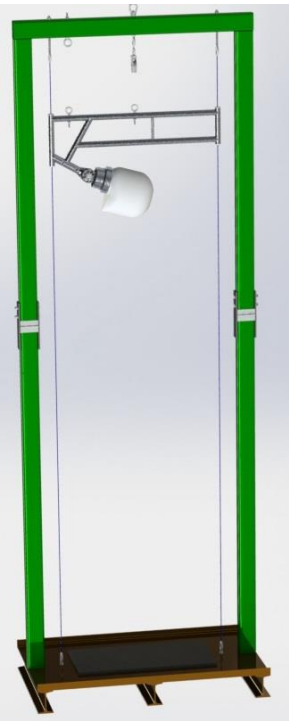

Figure 1. The human impact biomechanics research drop tower

Helmet research and concussions risk quantification is controlled through the standards of the National Operating Committee on Standard for Athletic Equipment, or NOCSAE. They have a standard design for a helmet impact test apparatus, however this design will not work for Cal Poly. Their design requires connecting parts of the machine to the wall and floor, something that is not very easy to do at Cal Poly. Because of this a new design needs to be thought of to enable the capability to helmet and other impact research to be brought to Cal Poly. The design will have to be changed from a permanently mounted fixture that weighs over 700lbs to a more manageable fixture that can be easily moved around Cal Poly for the various departments that may want to do research. The new design will have to be robust but light, something that is not always very easy to do. A lot of innovation will be needed to be able to accomplish this design task.

Luckily, through work of graduate students in the Mechanical Engineering department as Cal Poly a design that will work for helmet and human impact research has been designed, as seen in Figure 1. The machine is a twin-wire drop tower, meaning that the helmet is guided into impact surface by two steel cables. The machine meets a majority of the specifications of the NOCSAE standards and could be brought up to the standards very easily by adding the parts back which were removed to save weight.

This equipment along with its instrumentation will allow a lot of new research and lab opportunities to be brought to multiple Cal Poly departments. Besides being able to test any kind of helmet, from football to motorcycle and more, the machine can be easily outfitted to do leg impacts or chest impacts, two other highly studied impact cases.

III. Objectives

1. Build Drop Tower

   The building of the drop tower is the primary objective, this will allow for future research into impact biomechanics at Cal Poly.

2. Test Impact Diffusing Football Helmet Design

   Testing the new football helmet design will potentially allow a new design for football helmets to come to the market and allow for a potentially safer game.

IV. Methodology

The first step required to achieve a functioning drop tower will be to acquire all the parts and begin building the machine in the Cal Poly machine shops. Using manual and CNC machining the parts will be manufactured and assembled. Once, the machine is assembled the instrumentation will have to be calibrated by using a known sample of a current football helmet. With a calibrated machine a series of experimental and control samples will be run and then statistically compared to determine if the risk of concussion is reduced.

V. Timeline

- Receipt of materials and start of Manufacturing – 2/15/16
- End of Manufacturing – 3/11/16
- Machine Operational and Calibrated – 4/1/16
- Helmet Testing Completed – 4/29/16
- Data Analysis Completed – 5/13/16

VI. Final Products and Dissemination

The final products will include two theses and the testing machine itself. The theses will be published online through the library. Additionally, journal articles based off of the theses may be published in peer review journals if the helmet design's inventor allows it.

The physical machine will be kept in the inventory of the Mechanical Engineering department, but available for use by any department or research team which wishes to do helmet or any sort of human impact biomechanics research.

VII. Budget Justification

Line	Item	QTY	Pkg QTY	Net Price	Price	Source	Part
1	2x3 Steel Rect Tubing 3/16" Wall (per ft)	22			$ 104.00	B&B Metals	Frame
2	1/4 Inch Steel Plate 24"x48"	1			$ 70.00	B&B Metals	Frame
3	S 4x7.7 Beam (per ft)	6			$ 50.00	B&B Metals	Frame
4	1 x 1 x 1/8 Steel Angle (per ft)	7			$ 15.00	B&B Metals	Frame
5	1" Diameter Aluminum Tubing .083 Wall (per ft)	7			$ 32.52	Online Metals	Carriage
6	1.25" Diameter Aluminum Tubing .083 Wall (per ft)	1			$ 10.05	Online Metals	Carriage
7	0.5" Diameter Aluminum Tubing .083 Wall (per ft)	1			$ 5.72	Online Metals	Carriage
8	1" Diameter Delrin Rod 4" long (8576K21)	1			$ 5.06	McMaster	Bushings
9	Aluminum 2024 2 5/8 Dia x 7" long	1			$ 49.56	Online Metals	Headform Stem
10	Aluminum 2024 3 Dia x 4" long	1			$ 40.40	Online Metals	Headform Rotator
11	16175A61	2	1	$ 4.45	$ 8.90	McMaster	Surface-Mount Hinge
12	97245A442	4	5	$ 7.08	$ 7.08	McMaster	Clevis Pin, 1/2" Dia, 4" Len
13	3014T956	2	1	$ 3.15	$ 6.30	McMaster	Eyebolt with Shoulder, 3/8"-16
14	96282A103	2	50	$ 6.98	$ 6.98	McMaster	Serrated-Flange Locknut, 3/8"-16
15	3013T969	2	1	$ 8.23	$ 16.46	McMaster	Eyebolt without Shoulder, 3/8"-16
16	93298A130	2	50	$ 7.60	$ 7.60	McMaster	Nylon-Insert Flange Locknut
17	3099T13	1	1	$ 11.88	$ 11.88	McMaster	Pulley
18	3014T906	1	1	$ 13.88	$ 13.88	McMaster	Eyebolt with Shoulder, 3/8"-16
19	3274T41	1	1	$ 6.83	$ 6.83	McMaster	Oval Eye Nut
20	93298A110	2	100	$ 7.48	$ 7.48	McMaster	Nylon-Insert Nonmarring Flange Locknut
21	3014T901	2	1	$ 10.22	$ 20.44	McMaster	Eyebolt with Shoulder, 1/4"-20 Thread Size
22	91259A624	1	1	$ 1.54	$ 1.54	McMaster	Shoulder Screw, 3/8" Dia, 5/16"-18
23	95462A030	1	100	$ 6.44	$ 6.44	McMaster	Hex Nut, 5/16"-18
24	90850A150	1	50	$ 8.55	$ 8.55	McMaster	Flat Washer, 5/16" Screw Size
25	3014T905	1	1	$ 13.94	$ 13.94	McMaster	Eyebolt with Shoulder, 5/16"-18
26	93298A120	1	50	$ 5.45	$ 5.45	McMaster	Flange Locknut, 5/16"-18
27	8635K818	1	1	$ 53.45	$ 53.45	McMaster	Rubber, 1/2" Thick, 12" x 24", 40A Duro
28	3461T37 (per ft)	25	1	$ 0.87	$ 21.75	McMaster	Stainless Steel Wire Rope, 1/8" Dia
29	5513T12	4	1	$ 3.53	$ 14.12	McMaster	Wire Rope Clamp
30	3494T11	4	1	$ 0.63	$ 2.52	McMaster	Wire Rope Thimble
31	8494T12	1	1	$ 5.36	$ 5.36	McMaster	Anchor Shackle
32	92375A325	4	10	$ 10.23	$ 10.23	McMaster	Hairpin Cotter Pin
33	6061 2" Square Tube, 3' long	1		$ 27.83	$ 27.83	Online Metals	Lift Bar
34	Headform	1		$ 500.00	$ 500.00		
35	5698K214	1		$ 49.48	$ 49.48	McMaster	24V Electromagnet
36	750R-2C-24D	4		$ 7.75	$ 31.00	Automation Direct	24VDC Coil DPDT Relay
37	750-2C-SKT	4		$ 4.25	$ 17.00	Automation Direct	Relay Socket
38	GCX3330-22	1		$ 14.50	$ 14.50	Automation Direct	3 Pos Knob, Return to Center
39	AEM2G71Z11-3	1		$ 28.00	$ 28.00	Automation Direct	Rod Limit Switch
40	AEM2G21Z11-3	1		$ 26.00	$ 26.00	Automation Direct	Plunger Limit Switch
41	GCX3203-24L	1		$ 14.00	$ 14.00	Automation Direct	Pushbutton
42	GCX3243-24L	1		$ 15.50	$ 15.50	Automation Direct	2 Pos Knob, Mom
43	ECX2055-24L	1		$ 8.50	$ 8.50	Automation Direct	LED Indicator
44	SA110-40SL	1		$ 13.50	$ 13.50	Automation Direct	4 Hole Pushbutton Enclosure
45	PSS24-100	1		$ 30.00	$ 30.00	Automation Direct	24V Power Supply
46	75065K660	1		$ 36.21	$ 36.21	McMaster	Enclosure (Relays and P.S.)
47	61672			$ 149.99	$ 149.99	Harbor Freight	Winch
48	356A02	1		$ 895.50	$ 895.50	PCB PiezoTronics	Triaxial Accel
49	034G25	1		$ 211.50	$ 211.50	PCB PiezoTronics	25' Accel Cable
50	482C05	1		$ 481.50	$ 481.50	PCB PiezoTronics	4-Channel Accel Power Supply
51	McMaster Carr Shipping				$ 50.00		
52	Automation Direct Shipping				$ -		
53	Online Metals Shipping				$ 24.10		
54	PCB Shipping				$ -		
55	Shop Labor (per hr)	20		$ 16.00	$ 320.00		
	TOTALS				**$ 3,583.60**		

Budget Sheet

Student Applicant(s):	Michael Schuster Steven Warnert
CENG Faculty Advisor:	Dr. Peter Schuster
Project Title:	**Requested Funding**
Travel *subtotal*	**$0**
Travel: In-state	**$**
Travel: Out-of-state	**$**
Travel: International	**$**
Operating Expenses *subtotal*	**$ 3263.60**
Non-computer Supplies & Materials	**$3189.60**
Computer Supplies & Materials	**$**
Software/Software Licenses	**$**
Printing/Duplication	**$**
Postage/Shipping	**$74.10**
Registration	**$**
Membership Dues & Subscriptions	**$**
Multimedia Services	**$**
Advertising	**$**
Journal Publication Costs	**$**
Contractual Services *subtotal*	**$320.00**
Contracted Services	**$320.00**
Equipment Rental/Lease Agreements	**$**
Service/Maintenance Agreements	**$**
TOTAL	**$3583.60**

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February 1, 2016

Baker and Koob Endowments Selection Committee

Dear Committee:

I am writing this letter to urge you to support the "Testing of the Impact Diffusing Football Helmet" project's proposal for funding from the Warren J. Baker Endowment for Excellence in Project-Based Learning and the Robert D. Koob Endowment for Student Success.

The "Testing of the Impact Diffusing Football Helmet" project is focused on developing a system for performing impact testing of football helmets and other head protective gear. This equipment will initially support the investigation of a new type of football helmet energy attenuator proposed by Brad Bartholomay, a Cal Poly graduate. Last year, Mr. Bartholomay sponsored a senior project team in biomedical engineering to evaluate the concept. This year, he is sponsoring two mechanical engineering graduate students to perform detailed analysis of the new helmet's response. The culmination of this year's work will be the testing of a prototype helmet in conditions similar to helmet certification tests. The "Testing of the Impact Diffusing Football Helmet" requests funds to develop a test system to complete this confirmation testing.

The most exciting aspect of this project is that the impact system the team has designed is capable of expanding Cal Poly's impact testing capabilities for the future. The design provides a compact, portable helmet testing setup that can be used for years to come to test helmets of various types in multiple impact configurations. This device will enable not only the current project sponsored by Mr. Bartholomay, but also future projects aiming to improve helmet design and head impact protection.

Michael Schuster and Steven Warnert are well-prepared to complete this project. They have both completed Cal Poly's rigorous mechanical engineering undergraduate program, including developing a mechanical system designs in their senior projects. They are both working on theses related to this project, including analysis, build, and test components. They have demonstrated through past project success and progress on the current project that they have the right skills.

I will advise the team throughout this project. The nature of the advising includes weekly meetings to review progress, identify issues, and resolve problems; reviewing periodic written documents; and interfacing with Mr. Bartholomay. Specific mechanical engineering department resources used in the project will include computer labs, 3-D printers, student machine shops, and mechanical test labs. Additional campus resources will include the library. Faculty in mechanical, biomedical, and industrial engineering will also be support resources to help the students with technical challenges.

I encourage you to support this application for the Baker/Koob endowments as a hands-on student project supporting interdisciplinary research. Please let me know if you have any questions about this project.

Sincerely,

Peter Schuster, Professor