Anteater Electric Racing -FSAE Electric Vehicle Racecar Team at UC Irvine

Project Thesis

Anteater Electric Racing's primary objective is to design, manufacture, and test an electric vehicle that is compliant with the Formula SAE (Society of Automotive Engineers, Intl.) rulebook and enter it in the FSAE California competition. The team works together to create a vehicle powered by electric motors that will compete in static and dynamic events. The events consist of design, presentation, cost, acceleration, skidpad, autocross, endurance and efficiency.

The team's goals emphasize safety, reliability, performance, low cost, and productibility. The team's goals are to be completely compliant with the FSAE rulebook, compete in all dynamic events at the FSAE competition, score top 10 in the FSAE competition overall, build the vehicle with a projected budget of $32,000 and manufacturing the vehicle's components with the available resources the team has.

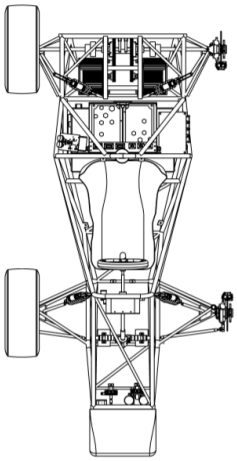
Team Purpose

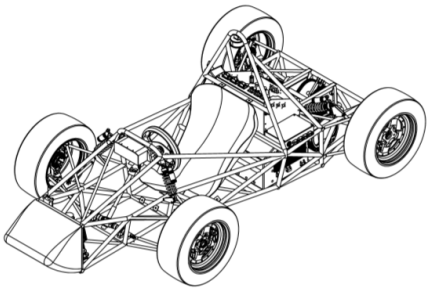
The Anteater Electric Racing program is committed to the team's development of technical and professional skills. This project offers students practical engineering skills, real world knowledge, design & manufacturing experience that would aid them in industry. Team members are challenged to design and build an all electric vehicle according to extensive FSAE technical regulations within 40 weeks. The FSAE competition also serves as an avenue for our student engineers to interact with industry representatives across the nation.

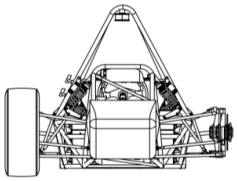
Competition & Vehicle Design Objective

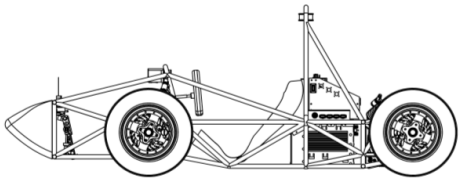
The objective of the FSAE competition is to provide students with an engineering design competition where students are given the opportunity to enhance their engineering design and project management skills. Students are able to apply the theories learned in the classroom in a challenging competition. The objective for the students is to develop and construct a formula race car to compete with other universities across the globe.

Vehicle Design is paramount to the competition - Teams are to assume a fictional manufacturing company has asked them to design, fabricate, test and demonstrate a one-off prototype vehicle. The vehicle should have high performance and high reliability to compete in all events, and will be judged on aesthetics, cost, ergonomics, maintainability and manufacturability. Each vehicle will participate in a series of Static and Dynamic events to determine the winner of the competition.









Static Events (in order)	Cost - 100 pts Presentation - 75 pts Design - 150 pts
Dynamic Events (in order)	Acceleration - 100 pts Skidpad - 75 pts Autocross - 125 pts Endurance - 275 pts Efficiency - 100 pts
Maximum Achievable Points	**1000 pts**

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Approach

The team is organized into two major systems - *Electrical* and *Mechanical* - with a respective Chief Engineer. Both major systems are composed of sub-teams with a sub-team lead and associate engineers.

The Electrical System is composed of the *Electronics, Embedded Systems,* and *Batteries* subsystems. The Mechanical System is composed of the *Aerodynamics & Body, Chassis, Human Interface, Suspension,* and *Powertrain* subteams.

Team Leadership of Anteater Electric Racing for 2022-2023.

The management team is in charge of the team structure and overviews the process of building, testing, and competing our electric vehicle in the FSAE Competition. Duties include document submissions, purchasing, communication protocols, presentations, status reports, and other administrative work to be completed.

Project Managers: [Redacted]
Chief Engineers: [Redacted]

Mechanical Subteams

Aerodynamics & Body

The Aerodynamics & Body team's responsibility is to design a body shell for the race car using CFRP (Carbon Fiber Reinforced Plastic) composites and developing an aero-package for the car (including rear spoilers, diffusers, vortex generating surfaces, front wings, sidepods, undertray). The design process involves CFD (Computational Fluid Dynamics) software modeling and wind tunnel testing of scaled prototypes to validate simulation results. Electric Vehicle aerodynamics is key to improving the vehicle efficiency and traction by providing the necessary down-force to the vehicle with minimal drag.

Lead: [Redacted]
Associates: [Redacted]

Chassis

The chassis is the primary structure of the car that encapsulates all subsystems of the electric vehicle together. The chassis subteam's primary objective is to manufacture a safe, lightweight, and structurally accurate chassis to pass the Structural Equivalency Sheet provided by SAE. Chassis members must thus have a solid understanding of the mechanics of structures during dynamic loading scenarios and be proficient in Solidworks. Significant time will be spent on assembling the chassis which involves welding profiled metal tubes together in four phases (front, cockpit, battery, and powertrain sections), a task requiring an understanding of proper manufacturing methods. Finite Element Analysis of the structure and physical testing will be utilized to ensure the reliability of this critical component, Which helps us develop a comparison between simulations and actual manufactured components.

Lead: [Redacted]
Associates: [Redacted]

Human Interface

The Human Interface sub team is responsible for mechanical systems the driver interacts with, including the steering system, seat and driver harness, pedal box, brake system, and water-resistant electronics enclosures. Human Interface Associates are to work closely with the driver and other corresponding team members to ensure a safe and comfortable ride with leverage to the vehicle controls. As this is a subjective matter based on driver preference, associates must learn communication to accommodate the driver and ensure they are confident in operating PETR, our 2022 Formula SAE electric racecar.

Leads: [Redacted]
Associates: [Redacted]

Suspension

The purpose of a vehicle's suspension is to maintain the tire's contact with the road and ensure that the tire remains in its optimal position under any and all conditions. The Suspension subteam is responsible for designing not only a reliable system but a system tolerable within all dynamic scenarios. The FSAE car is a student designed and driven race car prepared for a track, therefore safety, along with performance and handling will be prioritized.

Lead: [Redacted]
Associates: [Redacted]

Electrical Subteams

Batteries

The batteries subteam designs, builds, and tests the battery enclosure, battery mounts, thermal management system, and charging handcart. The batteries subteam is also responsible for the installation and care of the high-voltage (HV) system, which comprises the battery modules, the isolation relays, the battery management system, among other components. The HV system is a critical system with over 100 design rules. The primary design objective is to ensure the structural integrity of the enclosure, prevent the ingress of water and dirt, and protect the battery cells from over-temperature during peak racing conditions. We have completed much of the computer modeling, and verifications of the designs. The next steps include developing a full plan of manufacture.

Lead: [Redacted]
Associates: [Redacted]

Electronics

The Electronics subteam works on the electronic hardware components of the electric vehicle to integrate other systems together to run the vehicle safely. This team follows the most stringent technical rules of all subteams with over 200 rules requirements to fulfill and three documents to submit for competition. The Electrical Subteam has two main areas of focus.

The first area of focus is developing the Safety Systems including handling shutdown sequences in case of catastrophic failure. The second area of focus is developing robust and reliable electrical circuit boards that can handle the harsh environment of an electric vehicle.

Due to the urgency of safety required for this subsystem, all components produced by the Electrical subteam must go under stringent review - Design for Manufacturability, Failure Mode Analysis Effect, component bench tests, full system tests, and review by our faculty advisers and industry partners. Once the components are reviewed, they may be produced as a finalized Printed Circuit Board.

Leads: [Redacted]
Associates: [Redacted]

Embedded Systems

The Embedded Systems subteam is in charge of designing a system of programmable microcontrollers and sensor arrays for vehicle controls - including fault detection, throttle & brake plausibility and to monitor and control the motor of PETR.

Students in this subteam work with data interfaces such as Serial Peripheral Interfaces, Controller Area Network Bus, and Universal Asynchronous Receive/Transmit. Additionally this subteam is required to collaborate with the Electronics subteam to interface their microcontroller modules onto a working electrical circuit board.

Lead: [Redacted]
Associates: [Redacted]

Powertrain

The Powertrain system converts the drive of a single axial flux (AF) electric motor into mechanical rotational energy. Powertrain Associates are responsible for selecting the appropriate gear reduction for high acceleration performance and building continuous-velocity axles that can handle the instantaneous torque exerted on their system by the mtor. The subteam also builds the motor controller apparatus to monitor and safely supply the axial flux motor with energy from the battery system. Since the Powertrain Associates work with high voltage systems, electrical safety must be followed.

Lead: [Redacted]

Associates:, [Redacted]

Our Project Timeline for Spring 2022

Outlined by milestones. Certain deadlines and dates are not yet available as they have not been published to the SAE.org.

Task	Date	Status
Initial Budget	4/17/2021	Completed
SDP Proposal Due	4/28/2022	Completed
UROP Proposal Due	5/2/2022	Completed
Complete Design	12/1/2021	In Progress
Master Bill of Materials	11/22/2021	In Progress
Manufacturing Plan	12/1/2021	In Progress
Begin Manufacturing Phase of PETR	1/5/2021	Not Started
Register for FSAE Knowledge Event	Deadline not available	Not Started
Register for FSAE Validation Event	Deadline not available	Not Started
FSAE Business Presentation Documents Due	Deadline not available	Not Started
Subsystem Manufacturing Deadline	3/1/2023	Not Started
FSAE Business Presentation	Deadline not available	Not Started
Rolling Chassis	12/30/2022	Not Started
FSAE Design Presentation Documents Due	Deadline not available	Not Started
FSAE Cost Presentation Documents Due	Deadline not available	Not Started
Verification and testing plan finalized	2/28/2023	Not Started
Tech Ready Car	5/10/2023	Not Started
FSAE Cost Presentation	Dates not available	Not Started
FSAE Design Presentation	Dates not available	Not Started
FSAE Validation Event	Dates not available	Not Started
SCCA Autocross Event	Summer 2022	Not Started
Finish testing and validation	Winter 2023	Not Started

Itemized Budget & Justification

Units	Quantity	Item	Unit Price	Total
Aerodynamics-Body				
Each	3	⅛ “ Birch Plywood 4’x4’	35	$105.00
Each	4	XPS Foam 2’ x 2’	5.75	$25.00
Each	1	Anti Intrusion Plate	170	$170.00
Each	3	Sealant Tape	$8	$24.00
Each	1	Fibre Glast Nylon Vacuum Bagging Film	$25	$25.00
Each	1	Fibre Glast 4 Ounce Breather and Bleeder Cloth	$25	$25.00
Batteries & High Voltage				
Each	672	Molicel 21700 Batteries	$6.99	$4,697.28
Each	1	Delivery Cost of Battery modules	$118.73	$118.73
Each	10	Amphenol RL9100-103-F1	$11.19	$111.90
Each	10	ABS Sheet, 12" x 24" x 3/4"	$83.69	$836.90
Each	5	ABS Sheet, 12" x 24" x 1/4"	$28.93	$144.65
Each	2	0.09" Aluminum Sheet 5052-H32 (24”x36”)	$46.88	$93.76
Each	3	0.09" Aluminum Sheet 6061-T6 (12”x24”)	$29.03	$87.09
Each	2	0.125" Aluminum Sheet 6061-T6 (12”x24”)	$38.54	$77.08
Each	1	0.125" Aluminum Sheet 6061-T6 (24”x36”)	$49.53	$49.53
Each	6	Multipurpose 6061 Aluminum 90 Degree Angle with Round Edge, 1/8" Thickness, 1.25" Outside Height (1 ft)	$4.20	$25.20
Each	30	Aluminum Unthreaded Spacer 3/8" OD, 2-1/4" Long	$6.10	$183.00

Each	40	NTC Thermistor 33k Disc 5mm	$1.17	$46.8
Each	2	Loctite® 1808800 AA H3500™ Adhesive, 50 mL	$21.11	$42.22
Each	4	Low Carbon Steel U-Channel	$31.21	$124.84
Each	1	Easy-to-Machine 1251 Carbon Steel (1’x1”x1”)	$21.75	$21.75
each	1	Elcon HK-J-H650-6 Charger	$638.00	$638.00
each	1	AE40-EW-S12 DC/DC Convertor	$86.00	$86.00
each	7	18-8 Stainless Steel Low-Profile Socket Head Screw (8-32 Thread 3/8" long)	$8.72	$61.04
each	15	18-8 Stainless Steel Low-Profile Socket Head Screw (8-32 Thread 1" long)	$5.34	$80.10
each	16	18-8 Stainless Steel Helical Insert	$7.60	$121.60
each	20	7075 Aluminum bus bars	$2.71	$54.20
Chassis				
Each	4	84" x 1" x 0.095" Mild Steel Round Tube A513	$35.94	$143.75
Each	8	84" x 1" x 0.065" Mild Steel Round Tube A513	$44.21	$353.68
Each	8	84" x 1" x 0.049" Mild Steel Round Tube A513	$20.65	$165.2
Each	1	36" x 1" x 1" x 0.065" Mild Steel Square Tube A513	$5.36	$5.36
Each	1	84" x 0.75" x 0.035" Mild Steel Round Tube A513	$21.76	$21.76
Each	5	48" x 0.5" x 0.035" Mild Steel Round Tube A513	$5.30	$26.50
Set		Chassis Paint	$100.00	$100.00
Each	4	Lincoln Electric 0.030" Mild Steel Mig Wire	$16.49	$65.96
Each	12	Laser Cutting (Hours)	$8.00	$96.00

Each	16	1/4" x 2' x 2' Medium Density Fiberboard	$1.87	$29.92
Each	4	96" x 2" x 4" Lumber	$3.07	$12.28
Each	1	3" Coarse Threaded Lumber Hardware	$8.97	$8.97
Electronics				
Each	1	BMS	$1585	$1585
Each	2	Soldering Iron	$38.97	$77.94
Each	1	PowerStar 12V 3.3AH SLA Battery	$43.75	$43.75
Set	1	CSC Manufacturing	$75.79	$75.79
Set	1	PCC Manufacturing	$80.00	$80.00
Set	1	LPS Manufacturing	$72.00	$72.00
Set	1	CCMI Manufacturing	$138.80	$138.80
Set	1	BFB Manufacturing	$185.44	$185.44
Set	1	DASH Manufacturing	$100.00	$100.00
Set	1	HVI Manufacturing	$16.14	$16.14
Set	1	TSAL Manufacturing	$87.14	$87.14
Set	1	Brakelight Manufacturing	$15.00	$15.00
Embedded System				
Each	2	Hercules MicroControllers	$200.00	$400.00
Each	4	TI MSP430	$20.00	$80.00
Each	4	TI TMS57004 Development Board	$19.99	$79.96
Each	3	Raspberry Pi 3	$34.99	$104.97
Each	4	55100-3H-02-A-ND Digital Hall Effect Sensor	$8.98	$35.92
Each	20	N35P250125HT Magnet	$1.52	$30.40
Each	24	ZTP-115M Infrared Temperature Sensor	$10.90	$261.60
Each	3	Absolute Orientation Sensor 9-DOF LSM9DS0	$24.95	$74.85

Each	1	US Global Sat	$30	$30.00
Each	2	HDMI Cable	$7	$14.00
Each	5	Teensy 3.6	$30	$150
Each	30	Deutsch connector pins	$0.55	$16.50
Each	30	Deutsch connector sockets	$0.77	$23.10
Each	2	Hall Effect Sensors	$8.98	$17.96
Human Interface				
Each	N/A	Acrylic Sheet Laser Cutting	$20	$20
Each	1	Hyde Tools Plastic Cutting Tool	$5.99	$5.99
Each	1	Ground Low-Carbon Steel Sheet	$24.27	$48.54
Each	1	3M Dual Lock Fastener	$24.95	$24.95
Each	3	1/8" Clear Acrylic Plexiglass Sheets	$25.95	$77.85
Each	1	1/2" Clear Acrylic Plexiglass Sheet	$21.75	$23.44
Each	3	Hatchbox PLA Filament	$22.99	$68.97
Each	1	3D Print Water-Resistant Coating	$31.49	$31.49
Each	2	Rubber Sheet	$10.55	$21.10
Each	1	SCIGRIP Acrylic Cement	$4.99	$4.99
Each	2	Gorilla 100 Percent Silicone Sealant	$4.97	$9.94
Each	50	Mil. Spec. Phillips R.H. Screws	$7.00	$7.00
Each	50	Brass Screw-to-Expand Inserts	$12.00	$12.00
Each	100	Zinc-Plated Steel Pan Head Phillips Screws	$13.59	$13.59
Each	25	Aluminum Nylon Insert Nut	$4.32	$4.32
Each	25	Off-White Unthreaded Spacer (Standoff)	$11.36	$11.36
Each	3	1/8" Clear Acrylic Plexiglass Sheets	$25.95	$77.85
Each	25	Brass Screw-to-Expand Inserts	$9.30	$9.30
Each	120	Soft Buna O-Rings, Oil-Resistant	$10.00	$10.00
Each	100	Nickel Plated Brass Washer	$3.33	$3.33
Each	25	Low-Strength Steel Hex Head Screw	$5.61	$5.61

Each	4	Master Cylinder Mounts	$38.28	$38.28
Each	1	Speedway Standard Flaring Tool	$40.99	$40.99
Each	1	Al6061 Rectangular Bar	$31.17	$31.17
Each	1	HR Steel Plate	$17.91	$17.91
Each	1	Aluminum Plate 6061-T651	$3.69	$3.69
Each	50	Hex-Head Screw	$12.53	$12.53
Each	2	Aluminum Unthreaded Spacer	$4.03	$8.06
Each	6	Aluminum Unthreaded Spacer	$2.65	$15.90
Each	25	Hex Head Screw	$7.08	$7.08
Each	3	Bronze Sleeve Bearing	$1.42	$4.26
Each	2	Aluminum Unthreaded Spacer	$1.71	$3.42
Each	2	Aluminum Unthreaded Spacer	$1.71	$3.42
Each	2	Aluminum Unthreaded Spacer	$3.81	$7.62
Each	2	Aluminum Unthreaded Spacer	$3.57	$7.14
Each	2	Braided Stainless Brake Line	$15.74	$31.48
Each	1	Low Carbon Steel Tube	$20.72	$20.72
Each	1	Low Carbon Steel Tube	$23.30	$23.30
Each	2	Flanged-Sleeve Bearing	$5.94	$11.88
Each	2	Flanged-Sleeve Bearing	$1.70	$3.40
Each	1	Mild Steel Plate	$21.49	$42.98
Each	1	Brake Fluid DOT 3	$14.39	$14.39
Each	1	3/4"-36 Spline Steering Shaft	$46.16	$46.16
Each	1	Kart Seat	$253.31	$251.31
Suspension				
Each	2	.625" Steel Tubing	$46.48	$92.80
Each	8	Weld Cups (1.118" outer dia, 13/16 inner)	$16.99	$135.92
Each	16	Weldable Tube Ends 0.375"	$5.99	$95.84
Each	8	Spherical Bearing 3/8" Bore 13/16 OD	$11.16	$89.28
Each	4	Upright Fixtures (6061 Aluminum)	$200.00	$800.00

Each	2	3/8" High Misalignment Rod Ends (Toe Link fixture)	$10.68	$21.36
Each	2	Toe Link Fixtures (6061 Aluminium T6)	$100.66	$201.32
Each	2	Steering Fixture (6061 Aluminum T6)	$200.00	$400.00
Each	1	Rocker Arm (0.19 Aluminium Sheet 6061 T6 (12"x12"))	$23.16	$23.16
Each	24	3/8 Male Rod Ends	$4.07	$97.68
Each	4	2.5" ID washer	$4.49	$17.96
Each	8	Spherical Bearing 3/8" Bore 13/16 OD	$11.16	$89.28
Each	1	2 ft Multipurpose 6061 Aluminum Rectangular Tube	$29.38	$29.38
Each	3	Medium Density Fiberboard Sheet	$21.82	$65.46
		Powertrain		
Each	1	Emrax 228 - High Voltage	$4000.02	$4000.02
Each	2	RCV Drexler Tripod Housings	$260	$520
Each	1	Drexler Limited Slip Differential	$3093.75	$3093.75
Each	1	Cascadia Rinehart PM100DZ Motor Controller	$6240	$6240
Each	1	0.125" Aluminum Sheet 6061-T6 (12" x 36")	$49.53	$49.53
Each	2	0.5" x 2" x 12" Aluminum Rectangular Bar 6061 - T6	$6.56	$13.12
Each	2	0.09" Aluminum Sheet 5052 - H32 DFARS (12" x 24 ")	$45.51	$91.02
Each	1	0.09" Aluminum Sheet 5052 - H32 DFARS (24" x 36")	$107.27	$107.27
Each	1	0.09" Aluminum Sheet 5052 - H32 DFARS (24" x 24")	$73.14	$73.14

Each	1	0.5" x 12" Aluminum Round Bar 6061-T6	$8	$8
Each	2	0.625" x 1.5" Aluminum Rectangle Bar 6061-T6	$10	$20
Each	2	0.5" Aluminum Plate 6061-T6 (12" x 24")	$150.05	$300.10
		Manufacturing		
Each	4	Irwin Quick Grip 6inch D Mini Bar Clamp	$15.99	$63.96
Each	10	Dewalt High Performance Metal Grinding Wheel	$3.99	$39.90
			Total	**$28,756.29**

System Total is calculated from all the components listed to build an electric race car. The team's goal is to build PETR as the highest performing car in the program's history. A new motor paired with a higher voltage battery system and limited slip differential means better overall performance in acceleration, cornering, braking, and efficiency.

The team's account currently holds $14,819.94, however this number is not final as expenses for the previous year's car are still taking up funding. The team plans to fundraise through a ZotFunder where friends and family can donate to the team, a sponsorship package that will be sent out to various engineering companies, and continuing applying to school grants. The team is also dependent on the course fees associated with the project.

This Fall the Electric Vehicle Team is asking for a Grant of $2,500.00 from UROP to meet a portion of the needs to fulfill our budget. We believe this amount is appropriate as it reflects the amount received in previous years and will help the team reach our goal of successfully building an electric vehicle to compete in the Formula SAE California Competition.

Thank you for reading our proposal and our team looks forward to an invitation to attend the UROP Symposium with our completed project.