



**Hybrid
Electric
Vehicle
CHALLENGE**

United States
Department of Energy

SAE
INTERNATIONAL®

WELCOME...

Ford Motor Company in conjunction with the United States Department of Energy and the Society of Automotive Engineers is proud to welcome you to the 1993 Ford Hybrid Electric Vehicle Challenge.

The role that the hybrid electric vehicle (HEV) will play in the future of transportation has yet to be defined and the practicality of these vehicles for consumer use has yet to be proven. However, due to a growing concern for the environment, alternatives to gasoline-powered internal combustion engines are being sought. One of the best short-term solutions is the electric vehicle. Electric vehicles can be designed to perform similarly to conventional automobiles. They derive their energy supply from alternate power sources, emit no pollutants and are very quiet. While industry continues to develop the technology to build practical and efficient electric vehicles, the HEV has been developed as a compromise between pure electric and pure combustion engine vehicles. In addition, the HEV offers the practicality of a longer range than an electric vehicle. The HEV may help bring the automobile into harmony with the environment. Therefore, we feel that this is an important and practical engineering exercise for college students.

We believe that this competition may be the most technically challenging and instructive intercollegiate vehicle competition to date. This type of competition not only helps to develop students' technical skills, but also their teamwork and managerial skills. In fact, Ford is using this opportunity to provide project management experience for its new employees in the Ford College Graduate Program, a two-year training program. These newly hired engineers have been given the responsibility to manage this project.

Ford, DOE and SAE see the 1993 Hybrid Electric Vehicle Challenge as an opportunity to enhance the relationship between industry, government and academia. We genuinely believe that together we can pioneer changes in the automobiles of today, helping to make them an effective, practical and environmentally-sound part of the twenty-first century.

We would like to thank everyone for their efforts in making the 1993 Ford Hybrid Electric Vehicle Challenge a success and hope that this has been as great a learning experience for the students as it has been for us.

The Members of Ford Team Concept

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FORD MOTOR COMPANY, THE U.S. DEPARTMENT OF ENERGY, AND
THE SOCIETY OF AUTOMOTIVE ENGINEERS

ARE PROUD TO SPONSOR THE ...

FORD HYBRID ELECTRIC VEHICLE (HEV) CHALLENGE

**Thirty teams of university students are "charging"
into Dearborn on June 1st!!**

These teams have been diligently working since September of 1991 to design, build and develop hybrid electric vehicles for the Ford Hybrid Electric Vehicle Challenge taking place June 1 - 5, 1993 at Ford's Research and Engineering Center. These students are gaining an education that goes far beyond the classroom. With North America's growing concerns regarding the environment and our dependence on foreign oil, these students are trying to tackle a real-world problem in which there are "no answers in the back of the book."

ABOUT THE CHALLENGE

The Ford Hybrid Electric Vehicle Challenge is an intercollegiate competition that compels college students to look toward the future and develop designs for hybrid electric vehicles as a practical means of personal transportation. The student teams were given a choice of either converting a Ford Escort station wagon or constructing a hybrid from the ground up. A hybrid electric vehicle (HEV) has two sources of power used for propulsion; one or more electric motors and associated batteries, and an auxiliary power unit (APU). The APU may connect to the wheels directly and/or power a generator to make electricity for the electric motor(s). In the HEV Challenge, the APU is restricted to the use of denatured ethanol (E100), M85 (a blend of 85% methanol and 15% hydrocarbons), and reformulated regular unleaded gasoline.

ABOUT THE CHALLENGE (cont'd)

SPONSORS

Ford Motor Company is joined by the U.S. Department of Energy (DOE) and the Society of Automotive Engineers (SAE) in sponsoring the Challenge. In so doing, they hope to strengthen the cooperative link between the automotive industry, government, and leading engineering and technical colleges in North America and provide college students with an opportunity to take on some of the challenges currently facing the automotive industry. The sponsors expect the participating students to gain an ever-increasing interest in the automotive industry from their experiences in this competition. In addition, the sponsors hope to encourage all young people to study math and science and to pursue careers in engineering.

AWARDS

The participating teams will compete for awards in excess of \$75,000. Awards will be given to the overall winners and to top finishers in each competitive event for both the conversion and ground-up classes. Additional awards will be given in a variety of categories, including design innovation, safety, environmental friendliness, team spirit and best use of the HEV Challenge to generate interest in math and science amongst youths.

HEV CHALLENGE COMPETITIVE EVENTS AND SCORING

Dynamic Events	Date	Points	Static Events	Date	Points
Emissions	6/3	150	Engineering Design	6/2	150
Range	6/4	75	HEV Technical Report	6/2	75
HEV Commuter Challenge	6/5	150	Cost Assessment	6/3	125
Vehicle Efficiency	6/5	125	Oral Presentation	6/3	50
Acceleration	6/5	100			

All vehicles must pass Safety Inspections and Vehicle Qualifying prior to competing in dynamic events (6/1 - 6/2).

HEV CHALLENGE PARTICIPANTS

CONVERSION VEHICLES

<u>TEAM</u>	<u>VEHICLE NO.</u>
University of Alberta	8
California State University - Northridge	86
University of California - Irvine	17
Colorado School of Mines	10
Colorado State University	4
Concordia University	66
University of Illinois	88
Jordan College Energy Institute	77
Pennsylvania State University	11
Seattle University	0.1
Stanford University	100
Texas Tech University	0
U.S. Naval Academy	96
Washington University - St. Louis	23
Wayne State University	
Weber State University	6
West Virginia University	35
University of Wisconsin	110

GROUND-UP VEHICLES

<u>TEAM</u>	<u>VEHICLE NO.</u>
California State Polytechnic University - Pomona	233
California State Polytechnic University - San Luis Obispo	101
University of California - Davis	30
University of California - Santa Barbara	56
Cornell University	42
University of Idaho & Washington State University	31
Lawrence Technological University	1
Michigan State University	55
New York Institute of Technology	22
University of Tennessee	33
University of Texas - Arlington	93
University of Tulsa	3

SCHEDULE OF EVENTS

ACTIVITY	START TIME	END TIME
TUESDAY, JUNE 1		
Registration	7:30 a.m.	7:00 p.m.
Technical & Qualifying Inspections	8:00 a.m.	7:00 p.m.
Cost Assessment Inspections	8:30 a.m.	7:00 p.m.
Welcome Rally	8:00 p.m.	10:00 p.m.
WEDNESDAY, JUNE 2		
Registration	7:30 a.m.	3:00 p.m.
Technical & Qualifying Inspections	8:00 a.m.	6:00 p.m.
Cost Assessment Inspections	8:00 a.m.	6:00 p.m.
Written Report Debriefing	8:00 a.m.	5:00 p.m.
Engineering Design Events - Preliminary	8:30 a.m.	4:00 p.m.
*Opening Ceremony	11:00 a.m.	11:30 a.m.
Engineering Design Events - Final	7:30 p.m.	10:30 p.m.
THURSDAY, JUNE 3		
Emissions & APU Efficiency Events	8:00 a.m.	9:00 p.m.
Oral Presentations	8:00 a.m.	5:00 p.m.
Cost Assessment Inspections	8:00 a.m.	9:00 p.m.
Associate Sponsor Presentations	8:30 a.m.	5:00 p.m.
Practice	1:00 p.m.	10:00 p.m.
Design Center Walkaround	8:00 p.m.	10:00 p.m.
FRIDAY, JUNE 4		
Practice	8:00 a.m.	4:00 p.m.
*Range & Efficiency Events	8:00 a.m.	7:00 p.m.
(Pitstops at Ford Livonia Transmission & Chassis Plant and EPA Facility, Ann Arbor.)		
SATURDAY, JUNE 5 -- HEV Challenge Family Day		
Practice	8:00 a.m.	4:00 p.m.
*Acceleration Event	8:00 a.m.	11:00 a.m.
*Commuter Challenge Event	11:30 a.m.	5:00 p.m.
Awards Banquet	7:30 p.m.	10:30 p.m.

*Open to the public; see event descriptions for locations.

EVENT DESCRIPTIONS

COST EVENT

The goal of this event is to promote practical designs by factoring cost into the equation and provide an incentive to develop a cost effective vehicle. The schools will be scored on "Bang for the Buck" - where their score is arrived at by dividing the total dynamic points accumulated by the vehicle cost. The vehicle with the highest resulting value will win this event.

WRITTEN REPORTS

As part of the HEV Challenge, the teams were asked to write a technical report describing the design and operation strategy of their vehicles. The papers are in the standard SAE format and are judged by a team of Ford and industry experts. Points are awarded based on order of ranking. These papers will be published in an SAE special publication.

ENGINEERING DESIGN EVENT (day and evening sessions)

The objective of the Engineering Design Event is to judge the quality of design and construction (i.e. amount of engineering effort) that has gone into producing the vehicle as compared to other vehicles within the same class. The competition is organized such that there will be a preliminary design competition for all thirty vehicles, and a final design competition for the top three vehicles in each of the two categories, Ground-Up and Conversion.

The purpose of the Design Competition is to highlight the most outstanding vehicle designs of each class. As part of this event, the design judges will question student team members on aspects of the vehicle design. Similar questions will be asked of every school to facilitate ease of design score comparisons and rankings. The design judges will include both experts from outside of Ford and experts from Ford's Electric Vehicle Program.

ELECTRICAL EFFICIENCY

For the Electrical Efficiency segment of the Efficiency Event is designed to determine each vehicle's electric powertrain system efficiency. Energy measurements from an integrated Watt-hr meter will be made before the first full day of events while the vehicles have a full charge and then again at the end of that day, before the vehicles begin recharging. A measurement of the line energy delivered while the vehicles are recharging will also be made. These measurements will be used to calculate a characteristic loss factor for each vehicle. The loss factor is used to convert energy delivered to the vehicle from the charging station.

Energy measurements from the Watt-hr meters will be taken before and after the first 20 mile ZEV (Zero Emissions Vehicle, electric only) portion of the Range Event as well. These measurements along with the loss factor for each vehicle will be used to calculate the overall electric efficiency for each vehicle.

EVENT DESCRIPTIONS (cont'd)

EMISSION EVENT

This event will test APU (auxiliary power unit) exhaust emissions (HC, NMOG, CO, NOX) for all vehicles. The vehicles will be track prepped, if required. They will then be transported to the Ford test labs and evaluated in emission test cells. These tests are similar to those that production vehicles undergo today.

APU EFFICIENCY

The APU Efficiency event is designed to determine which school has the most efficient APU. The fuel economy of the APU will be used to rank the vehicles. Fuel economy will be determined by the carbon balance method which is calculated from the emission concentrations. This event will take place during the Emissions Event.

ORAL PRESENTATIONS

The Oral Presentation event gives each college team the opportunity to present information on their vehicle, highlighting selling points of their design. The oral presentation is limited to 10 minutes with an additional 5 minutes for questions from a panel of judges. The objective of the Oral Presentation event is to evaluate the teams' ability to make an informative and exciting presentation aimed at selling the benefits of their HEV.

RANGE EVENT

The goal of this event is to test the range of the vehicles in HEV and in ZEV mode. The vehicles will be driven on Michigan public roads from the Ford Dearborn Proving Grounds to the Michigan International Speedway, for a total time of 5 hours or approximately 200 miles. There will be one pitstop at Ford's Livonia Transmission & Chassis Plant and another at the Ann Arbor EPA facility. This event is open to the public.

OVERALL "HIGHWAY" EFFICIENCY

The Overall Efficiency event is designed to determine which school has the best overall strategy. Using a formula similar to the metro-Highway portion of CAFE (corporate average fuel economy), city and highway efficiency will be monitored from both the electric and liquid fuel standpoints. The "highway" efficiency will be monitored during the HEV (over the road) phase of the Range event. The "city" efficiency will be monitored during the Commuter Challenge on Saturday, June 5.

EVENT DESCRIPTIONS (cont'd)

ACCELERATION

The Acceleration event is designed to test the ability of each HEV to accelerate from a standing start over a 100-meter distance, which simulates a start from a traffic light in an urban environment. Each HEV will have two opportunities to accelerate in Zero Emissions Vehicle (electric-only) mode and two opportunities in Hybrid Electric Vehicle (HEV) mode. The best elapsed time for each mode will be used for scoring. This is a 100 point event, with 50 points allocated for ZEV mode and 50 points HEV mode. The acceleration event will be held on the High Speed Straightaway at Dearborn Proving Grounds. This event is open to the public.

COMMUTER CHALLENGE

The goal of the HEV Commuter Challenge is to test the ability of the HEVs to negotiate a simulated urban environment. Numerous stop signs, tight corners, and mild traffic (from other HEVs) will challenge the vehicles. The HEV Commuter Challenge will be held on the Ride and Handling Course at Dearborn Proving Grounds, with the course modified slightly to keep the running speeds consistent with an urban environment. There will be two sessions, simulating a drive in from the suburbs to a city center and the return trip. Each session is 10 laps long.

The first session will have the first laps in Hybrid Electric Vehicle mode, the second five in Zero Emissions Vehicle mode. The second session will start with five laps in Zero Emissions Vehicle mode, with the last five laps in Hybrid Electric Vehicle mode. Efficiency measurements for the metro portion of the Overall Efficiency event will be made during this event.

Corrected elapsed time for this event will include penalties for running stop signs, hitting course markers, or using the APU during the Zero Emissions Vehicle portion of the event. The best session time will be used for scoring. This is a 150 point event. This event is open to the public.

1993 HEV CHALLENGE PARTICIPANTS

Ground-up Class

Team	Vehicle Name	# of Students Involved	Faculty Advisor	Fuel Type /Capacity	GVW (lbs)	CHASSIS		Battery	
						Type	Material	Type	Pack Voltage
CA Poly -SLO	Shockwave	40	Safwat Mustafa	Gas/6g	2300	Tubular Std.	Steel	PB ACID	120
CA Poly -Pomona	APEX	35-40	Thomas Barwell	Gas/5g	2000	Spaceframe	Steel	PB ACID	120
Cornell U.	The Blizzard	38	Richard Warkentin	M85/8g	2300	Spaceframe	Chromoly Std.	PB ACID	120
Lawrence Tech U.	Response		Charles Schwartz	Gas	2744	Spaceframe	Steel	PB ACID	240
Michigan State U.	Spartan Charge	62	John Gerrish	Gas/7.5g	2933	Monocoque	Aluminum	Ni MH	262
NY Institute of Tech		35	Prof. Beheshti	M85/8g	2000	Monocoque	Aluminum	PB ACID	96
UC -Davis	Ground FX	25	Andrew Frank	Gas/2g	1600	Spaceframe	Aluminum	NICAD	195
UC -Santa Barbara	200 proof	30	DiNapoli	Ethanol/10g	2100	Spaceframe	Steel	PB ACID	144
U. of ID & Wash. S	Caburglar	80	Dean Edwards Dr. de Sam Lazaro	Gas/12g	3800	Spaceframe	Aluminum	PB ACID	336
U. of Tennessee	High Potential	60	Adams/Snyder Hodgson/Symonds	Gas/8g	2400	Spaceframe	Steel	PB ACID	180
U. of Texas -Arlington	High Bred	15	Robert Woods	M85/10g	1700	Spaceframe	Steel	NICAD	144
U. of Tulsa	Hybrid Hurricane	24	John Henshaw	Gas/4.35g	3000	Monocoque	PVC &	PB ACID	264
							Strcd. Foam		

Note: Data current at time of printing

1993 HEV CHALLENGE PARTICIPANTS (cont'd)

Ground-up Class, continued

Team	APU			Motor			Estimated Performance			
	Manufacturer	Horse Power	Size	Manufacturer	Type	Rating	ZEV Range	HEV Range	Acceleration	Top Speed
CA Poly-SLO	Geo Metro	49	1 Litre	Solectria	AC	25 hp	40	340	NA	85
CA Poly-Pomona	Kawasaki	16		Advanced Dc	DC	19hp	25-30	NA	0-50 12s	55
Cornell U.	Briggs&Stratton	18	540cc	Solectria AC	AC	28hp	67	152	0-50 10.5s	68
Lawrence Tech U.	Geo Metro	50	1 Litre	Advanced DC	DC	42hp				
				Magnetec	AC	20 hp	NA	NA	NA	NA
Michigan State U.	Geo Metro	47	993cc	GE	AC	15 hp	30	410	0-50 17s	75
NY Institute of Tech	Kawasaki	20	617cc	Advanced DC	DC	8 hp	30	280	0-60 18s	73
UC-Davis	Briggs&Stratton	18	35in3	Unique Mobility	DC	40 hp	40-100	"unlimited"	NA	120
UC-Santa Barbara	Suzuki	52	993cc	Solectria	AC	15N*m	40	200	0-50 8s	85
U. of ID & Wash. S	Kohler Comnd	20	624 cc	AC Propulsion	AC	100 kw	100	420	0-50 <10s	75
U. of Tennessee	Kohler	20	600 cc	Unique Mobility	DC	25 hp	30	90	NA	NA
U. of Texas -Arlington	Honda Hurricane	100	600 cc	Solectria	DC	16hp	45	245	0-50 7s	125
U. of Tulsa	Honda	12.2	6.5 kw	Baldor	AC	15 hp	48	200	0-50 15s	60

1993 HEV CHALLENGE PARTICIPANTS (cont'd)

Conversion Class

Team	Vehicle Name	#of Students Involved	Faculty Advisor	Fuel Type /Capacity	GVW (lbs)	Battery		APU		
						Type	Pack Voltage	Manufacturer	Horse Power	Size
CSU -Northridge	Voltswagon	40	Tim Fox	M85/13.5g	3100	PB ACID	120	Kawasaki	19	248cc
	Blaster	50	David Munuz	Ethanol/8g	3400	NICAD	120	Suzuki	30	
CO State U.	Ice Wagon	30	Bryon Winn	Gas/8g		PB ACID	180	Kawasaki	22	
Concordia U.	Electra	15	Tadeusz Krepec	Gas/11.9g	3527	PB ACID	144	Briggs & Stratton	16	
Jordan College E.I.	Ecosort		Paul Zellar	M85/6g		PB ACID	120	Kawasaki	18	500cc
Pennsylvania State U.	Electric Lion		Kon-Well Wang	Gas		PB ACID	144	Geo Metro	49	993cc
Seattle U.	MACH.1	20	Ray Murphy	Gas/8-10g	3812	PB ACID	192	Geo Metro	50	993cc
Stanford U.	The Winds of Freedom	40	Martin Hellman	Gas/12g	3200+	NICAD	108	Honda	25	250cc
Texas Tech U.	The Dream Machine	25	Jones/Maxwell Parten/Ernst	Ethanol/11.9g	3812	PB ACID	144	Kawasaki	40	650cc
U. S. Naval Academy	AMPhibian		Greg Davis	Gas/12g		PB ACID	96	Briggs & Stratton	18	
U. of Alberta	Emission Impossible	50-80	David Checkel	Gas/7g	3200	NICAD	170	Suzuki Swift	55	1 litre
U. of CA -Irvine	Elant 3		Roland Schinzinger		<3800	PB ACID	288	Suzuki	65	1 litre
U. of Illinois	The Chief	200	Robert White	Ethanol/7g	3666	PB ACID	336	Kawasaki	22	620cc
U. of Wisconsin	Paradigm	50	John Moskwa	M85/12g	3650	PB ACID	400	Kohler	22	630cc
Wash. U. -St. Louis	Sting	9	Richard Rabbitt	Ethanol/8g	3400	PB ACID	120	Briggs&Stratton	20-25	480cc
Wayne State U.	Waynesort	8	Jerome Meisel	Gas		PB ACID	240	Escort	90	1.9l
Weber State U.	Wild Cat		David Erb	Gas/15g	>3732	PB ACID	88.7	motorcycle	40	450cc
West Virginia U.	ZAP	39	Parviz Famouri	M85/12		PB ACID	96	Kawasaki	20	617 cc

Note: Data current at time of printing

1993 HEV CHALLENGE PARTICIPANTS (cont'd)

Conversion Class, continued

Team	Motor		Estimated Performance				
	Manufacturer	Type	Rating	ZEV Range (miles)	HEV Range (miles)	Acceleration (mph)	Top Speed (mph)
CSU -Northridge	Unique Mobility	DC	20 hp	42	200+	0-40 9.5s	62
CO School of Mines							
	Advanced DC	DC	28 hp	40	200	0-40 18s	40-45
CO State U.							
	Unique Mobility	DC	34 kw	54	340	0-50 10-12s	80
Concordia U.							
	Solectria	DC	30 hp	40	160	0-45 13s	55
Jordan College E.I.	Advanced DC	DC	50 hp				
	Advanced DC	DC	20 hp	60	160	NA	NA
Pennsylvania State U.	Solectria	2-AC		NA	NA	NA	NA
Seattle U.							
	UNIQ	DC	43 hp	55	220	0-50 16s	60
Stanford U.							
	FMC/Stanford	AC	75 hp	75	600	0-50 <10s	88
Texas Tech U.	Solectria	2	28 hp	40	200	NA	50
U. S. Naval Academy	GE	DC	20.9 hp	NA	NA	NA	NA
U. of Alberta							
	Solectria	2 DC	16 hp	60	300	0-50 11s	90
U. of CA -Irvine							
	Electra-Gear	AC	20 hp	40	250+	0-50 10s	75
U. of Illinois							
	Magnatec	AC	25 hp	40	460	0-50 9s	108
U. of Wisconsin							
	Electric Apparatus	AC	50 hp	40+	200+	0-50 14s	70
Wash. U. -St. Louis							
	Advanced DC	DC	20 hp	40	250	0-50 15s	65-70
Wayne State U.	Garret Research	2 DC	11 kw	40	200	0-50 <12s	60
Weber State U.							
	Advanced DC	DC	19 hp	60	200	0-35 15s	NA
West Virginia U.	Advanced DC	DC	20 hp	40+	160+	0-50 15s	60

ABOUT THE SPONSORS

FORD TEAM CONCEPT

FORD TEAM CONCEPT (FTC) is a voluntary group of approximately 100 employees from various divisions of Ford Motor Company. Many are currently involved with or have previously taken part in the Ford College Graduate (FCG) Training Program. The FTC team originated in March, 1991 when the Ford College Sponsors called together a group of FCG's to examine the possibility of hosting a college contest that would strengthen Ford's involvement with the country's leading engineering schools.

FTC developed the "Hybrid Electric Vehicle Challenge" in conjunction with representatives of the U.S. Department of Energy and the Society of Automotive Engineers. The primary objectives for this program are:

- To strengthen the cooperative link between the auto industry and leading engineering schools in the country.
- To provide participating schools and students with the opportunity to deal with new automotive technology and its potential applications.
- To increase the pool of highly motivated graduates who are familiar with state of the art technology and are excited about its applications within the auto industry.
- To increase public awareness of the co-sponsor's efforts to produce environmentally-conscious vehicles.

FTC reports to a steering team made up of representatives from the Ford College Sponsors Committee and to Dr. John P. McTague, vice president - Technical Affairs. Members work on the project outside their normal job responsibilities, contributing their personal time for the good of the program.

FTC would like to thank Ford Motor Company, its management, all of the individual Ford Divisions, our co-sponsors, the United States Department of Energy, the Society of Automotive Engineers, the numerous individuals that stepped forward and graciously volunteered their time and resources, and most importantly the students and faculty advisors for their cooperation and hardwork in making the HEV Challenge a reality.

ABOUT THE SPONSORS (cont'd)

DOE/ARGONNE NATIONAL LABORATORY 1993 HEV CHALLENGE INVOLVEMENT

The U.S. Department of Energy continues its ongoing support of advanced automotive technology through its sponsorship of the 1993 HEV Challenge. This event joins a long list of Engineering Research Competitions (ERCs) through which DOE encourages research into advanced transportation technologies and alternative fuels, providing students with the opportunity to demonstrate the performance of their vehicles in a safe and controlled environment. Rigorous testing of student designs in ERCs produce valuable comparative data on new technologies. The competitions place a high premium on engineering excellence, thorough testing and development and innovative solutions to real world problems.

DOE's role in the HEV Challenge, administered by Argonne National Laboratory's Center for Transportation Research, also includes data collection and analysis, technical assessments and post-competition activities. In addition to providing sponsorship, financial support and awards to the schools in 1993, DOE has announced plans for a 1994 HEV Challenge in which teams from 1993 can further develop and refine their HEV Designs.

SAE 1993 HEV CHALLENGE INVOLVEMENT

The Society of Automotive Engineers (SAE) has been involved with collegiate engineering competitions for close to twenty years as part of the Society's mission to "influence and enhance the formal educational process in mobility technology." Through sponsorship of eight annual events (Formula SAE®, the East, West and Midwest Mini Baja® events, the Supermileage and West Coast Supermileage fuel economy events, the Aero Design radio-controlled aircraft event and the Walking Machine Decathlon) and co-sponsorship of various alternative fuel events, SAE is helping to ensure the technical competence of each new class of mobility industry engineers.

SAE is an engineering society of over 60,000 members from all engineering and scientific disciplines who are dedicated to advancing mobility technology. Students annually make up close to twenty percent (20%) of SAE's membership and are concentrated in more than 240 SAE Student Chapters on campuses in the U.S. and abroad.

Special recognition goes to the HEV Challenge Associate Sponsors. These sponsors have provided generously to help make this event a success. On behalf of Ford, the U.S. Department of Energy, the Society of Automotive Engineers and all the participating teams, THANKS FOR YOUR SUPPORT!

**1993 HEV CHALLENGE
ASSOCIATE SPONSORS**

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This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There is no text or other markings on the paper.

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This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are approximately 20 lines visible. A small, faint yellowish mark is present near the center of the page. The bottom edge of the paper shows some slight waviness or shadowing, suggesting it might be part of a bound notebook.

This image shows a single sheet of white paper with horizontal blue or grey ruling lines. The lines are evenly spaced and run across the width of the page. There is no handwriting or other markings on the paper.

