45th Conference on Senior Engineering Design Projects

College of Engineering and Applied Sciences

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45TH CONFERENCE ON
SENIOR ENGINEERING DESIGN
Tuesday, December 9, 2009, 9a.m. to 3p.m.
College of Engineering and Applied Sciences
--Directions--

From I-94
At exit #74, turn north onto U.S. 131, go 2.8 miles, follow the directions listed below for U.S. 131.

From U.S. 131
At exit #36A, turn east onto Stadium Drive. Turn right at first light which is Drake Rd. Continue on Drake Rd. through the next light (at Parkview Ave.) into the WMU Parkview Campus. You will now be on Campus Drive.

From WMU Main Campus
From the corner of Stadium Dr. and Howard, go west on Stadium Dr. until you come to Drake Rd. Turn left onto Drake and continue south through the next light (at Parkview Ave.) and into the WMU Parkview Campus. You will now be on Campus Drive.
You are invited to attend the forty-fifth Conference on Senior Engineering Design Projects. The conference will be held from 9 a.m. to 3:00 p.m., **Tuesday, December 8th, 2009** at the College of Engineering and Applied Sciences on the Parkview Campus of Western Michigan University. The College of Engineering and Applied Sciences sponsors the conference to showcase the work of its graduating seniors, who are required to complete a capstone project that puts into practice what they have learned. Many of the projects are sponsored by business and industry. The conference is **free** and open to the public. You are welcome to attend all or part of the day's events. Reservations are not necessary.

**High school and community college** teachers are encouraged to bring students to the conference. Buses can drop off passengers in the College Circle in front of the building and then park in lot P-2. (See map)

**Parking** is available in the ramps behind the College of Engineering and Applied Sciences (See Map: Lots P3 and P4). There is no charge for parking for those attending the Conference.

**Presentations begin on the hour and half hour.** Please do not enter a room after a presentation has begun.

**Session locations, times, and page number for project descriptions:**

| Civil and Construction Engineering | D-204/5 | 10 a.m. to 11 a.m. | p. 5 |
| Computer Science                  | D-208   | 9 a.m. to 11:30 a.m. | p. 6 |
| Electrical and Computer Engineering| D-115   | 9 a.m. to 11:30 a.m. | p. 8 |
| Industrial and Manufacturing Engineering| D-201 | 9 a.m. to 2 p.m. | p. 10 |
| Mechanical and Aeronautical Engineering| D-109 | 9 a.m. to 3 p.m. | p. 13 |
| Paper Eng., Chemical Eng., and Imaging| D-204/5 | 9 a.m. to 10 a.m. | p. 17 |

A lunch break is scheduled from 12 p.m. to 1 p.m. There is a café available on site. **For more information about the conference**, call Tamara Bergman at (269) 276-3248.

Brochure available electronically at:

http://www.wmich.edu/engineer/senior-design-conference.htm
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THANK YOU

The College of Engineering and Applied Sciences is grateful to these sponsors that have provided or cooperated in Senior Engineering Design Projects being presented in December 2009. If you have a project for our students or if you would like more information, please call Tamara Bergman at (269) 276-3248.

City of Battle Creek Wastewater Division
Denso Manufacturing Michigan, Inc.
Eaton Corporation
Kalamazoo Animal Rescue
Kalamazoo County Road Commission
Kalamazoo Loaves & Fishes Warehouse
Kalamazoo Public Library
Panther Arms
Reflex Industries, Inc.
Stryker Medical
TechCare TronLabs
Western Herald
WMU School of Music
In order to optimize the use of funds for future road maintenance, detailed scheduling and planning must be implemented before the road work begins. It is very important to be able to effectively analyze the conditions of our road system in order to allocate a plan for future spending. The Pavement Surface Evaluation and Rating, or PASER system, is the tool used to take inventory and determine the shape of the roads from year to year. Using this system, existing road conditions will be evaluated and a projected maintenance schedule will be constructed to determine where current funding will be spent.

The City of Battle Creek Wastewater Treatment Plant provides municipal and industrial waste treatment to a connected population of 80,000 people. The plant receives an unusually high strength waste stream due to the sugar and carbohydrate waste produced by the cereal manufacturers in the city. This high strength waste creates an excessive demand for oxygen within the activated sludge system which in turn results in high electrical cost for the City of Battle Creek. A plant optimization study was conducted to determine alternative methods that can be used to reduce annual operating cost. Capital improvements were recommended based on the results of economic analysis.
ELECTRONIC STUDENT TRACKING AND RESPONSE SERVICES (eSTaRS)
by Komin Antony and Andrew Messner
Faculty Advisors: John Kapenga and Karlis Kaugars
9:00 a.m. to 9:25 a.m., D-208

Taking roll is an essential part of any class, doing so in a large lecture however is cumbersome and time consuming. The eSTaRS software allows faculty to track attendance by having students swipe their Bronco cards. Students regularly missing class will be identified and an email will be sent to their resident advisors. The core application, recording the swipes, was coded in C# and the web interface, used to view and manage student information, was written using PHP and MySQL. Notifying instructors and advisors about struggling students offers the opportunity to resolve students’ issues before they greatly hinder their success.

PINEWOOD DERBY RACE MANAGER
by Ben Mechling and Joel Smith
Faculty Advisor: John Kapenga
9:30 a.m. to 9:55 a.m., D-208

Although software has been developed for managing pinewood derby race races, no system provided support for large, regional competitions. An Apache web server provided with the XAMPP package was used to make a set of web interfaces accessible from various stations of the competition. PHP was used to generate the pages and interface with a MySQL database. The web pages employ JavaScript to communicate with the server and update the content of the pages. Future development is likely to include an interface for finish-line hardware.

DIGITAL SIGNAGE MANAGEMENT SYSTEM
by David Adams and Christopher Gore
Sponsors: Jim Clarey and Kevin King, Kalamazoo Public Library
Faculty Advisor: Ala Al-Fuqaha
10:00 a.m. to 10:25 a.m., D-208

Disseminating information to patrons is important for cultivating an active library community. In recent years, it has become popular for institutions to display pertinent information, such as events and workshops, at their facilities on digital screens. A digital signage management system was created to organize library content to be displayed on multiple screens across several library branches and administered through a centralized database. This was implemented using Microsoft’s .Net framework. The system is simple to use and can be maintained with little to no training.
REDESIGN AND IMPROVEMENT OF PET FOSTER SYSTEM WEBSITE
by Kristen Farra and Bryan Mitchell
Sponsors: Aaron Graham and Aaron Whiteaker, Kalamazoo Animal Rescue
Faculty Advisor: John Kapenga
10:30 a.m. to 10:55 a.m., D-208

A web-based nonprofit organization needs an efficient and secure site. A web application for maintaining information on fostered pets was redesigned to improve security and allow ease of use for the site’s administrators. Varied levels of access for volunteers were implemented to enhance security, database restructuring eliminated obsolete records, and automation of the pet information entry system further streamlined the process of making adoptable pets visible. MySQL and PHP were used to develop the database and the site. The website allows the volunteers to find permanent homes for pets more efficiently.

HARVEST HELPER – FARMING ASSISTANCE SOFTWARE
by Gregory Ferrell, Joseph Smit, and Mark Yake
Faculty Advisors: John Kapenga and Ala Al-Fuqaha
11:00 a.m. to 11:25 a.m., D-208

Data acquisition in agricultural operations can provide a wealth of information to assist farmers in running a more compliant, efficient, and productive farm business. A web application, to collect and report this valuable data, was created using several development tools including: ASP.NET, LINQ, and Microsoft SQL Server 2005. This application allows tracking and reporting of chemical use, fertigation, integrated pest management program data, and production yields. The data is used for trend analysis, research, and regulatory report generation. Analysis of aggregated data will be used to improve future yields and product quality, while reducing overall costs.
Clutch actuators in heavy duty trucks that are presumed faulty are generally returned to the manufacturer. Therefore, an automated test stand was needed to determine if the unit works as intended. A test fixture was created to assess an actuator’s performance and functionality. Tests include successful CAN (Control Area Network) communication, torque output, and response time of the actuator. Test sequencing was completed using LabVIEW to automate the test process and derive an objective test result. The completed test system provides pass or fail outcome to the operator, while also recording detailed data from each tested unit for future engineering analysis.

There is a communication barrier between those who speak with words and those who speak with their hands. The Arm and Hand Gesture Interpreter provides a proof of concept for a system which can help alleviate this problem. The system monitors the user’s hand and finger movements with accelerometers, gyroscopes, and flexible resistors. The data collected by these sensors is used to determine where the user’s hand and fingers are in three dimensional space. The Arm and Hand Gesture Interpreter will segue into more advanced models which may be able to convert the user’s movements into audible speech.
EXOSKELETAL ROBOT ARM CONTROL SYSTEM
by Michael Gresenz, Mark Piotrowski, Rochelle Schwerin, and Pwint Than
Sponsor: Bill Forshey, Tech Care, TronLabs
Faculty Advisor: Ralph Tanner
10:00 a.m. to 10:25 a.m., D-115

An exoskeletal robot arm control system, used to assist people that have limited control over their arm was developed. The main task was to design the robot arm control system to assist vertical movements of a handicapped individual’s arm. Infrared, thermal, and force sensors gather data that is used in a microcontroller implemented artificial neural network. The neural network drives de stepper motors in the wearable arm. The arm’s control system has three modes to help the users operate the arm based on their needs.

HEMISPHERICAL SPEAKER ARRAY FOR LIVE ELECTRO-ACOUSTIC PERFORMANCE
by Daniel Lafond, Daniel LeCompte, and Robert Valentine
Sponsor: Dr. David Loberg Code, WMU School of Music
Faculty Advisor: Johnson Asumadu
10:30 a.m. to 10:55 a.m., D-115

A new approach to performing electronic music has been developed using laptop computers and hemispherical speaker arrays, allowing an electronic audio source to behave the same way that a performer playing an acoustic instrument would by projecting sound radially from the location of the instrument. The WMU School of Music wished to develop their own laptop orchestra but existing speaker arrays and amplifiers were too expensive. An internally-amplified speaker array, along with the supporting power conversion circuitry, was designed and built. It utilizes low cost integrated circuit power amplifiers to produce high quality and robust sound output.

RF GENERATOR FOR NERVE ABLATION
by Ray Farmer, Scott Keller, and Ryan Kerrigan
Sponsor: Mike Strickler, Stryker
Faculty Advisor: Damon Miller
11:00 a.m. to 11:25 a.m., D-115

Many people suffer from back pain. One effective treatment utilizes radio frequency energy to destroy nerve cells in the spine. Stryker leads the radio frequency nerve ablation market with its current product, the Stryker MultiGen™ RF Console. Prototype hardware and software were developed to test a new radio frequency generator intended to reduce the complexity and cost of the current design.
INDUSTRIAL AND MANUFACTURING ENGINEERING
Session Chairs – Betsy Aller and Bob White
Room D-201

DYNAMOMETER ROAD LOAD SIMULATOR
by Jordan Avery, Adam Blake, and Derek Kordalewski
Faculty Advisors: James VanDePolder and Thomas Sutton
9:00 a.m. to 9:25 a.m., D-201

Increased awareness of fuel economy (F.E.) and emissions has prompted a need to upgrade the current automotive lab chassis dynamometer to meet industry standards. An eddy current absorber was integrated onto the existing dynamometer, providing a way to simulate vehicle and road surface interaction. The configuration was designed (using Pro/ENGINEER) and Finite Element Analysis (using Pro/MECHANICA) was performed to address system constraints and structural integrity. A failsafe clutch mechanism was designed, fabricated, and tested to provide system functionality and ease of use. This integration will provide industry testing capabilities to better understand actual vehicle F.E. and emission performance.

PORTFOLIO MANAGEMENT TOOL FOR DATA-DRIVEN DECISION MAKING
by John Barnes, Chris Gray, Steve Johnson, and Tara Minich
Sponsor: Nolan Akerman, Stryker Medical
Faculty Advisor: Betsy Aller
9:30 a.m. to 9:55 a.m., D-201

Making the decision to continue, re-design, or eliminate a product is a difficult calculation for many companies. A management tool was developed to apply a scientific process to this decision. A decision-making methodology was created using exponentially weighted moving average (EWMA), control charting, and analysis techniques. This new methodology will permit quick assessment of readily available data and will result in portfolio decisions that are both based on tangible evidence and easily defendable.
Many families are finding it difficult to survive in the current economic downturn. Optimizing the way that emergency food services operate is vital. Warehouse management systems were researched and adapted to meet the need for organizations that do not have a constant income, workforce, or customer base. Time studies, process/product flow diagrams, motion studies, and activity relationship charts were used to optimize the warehouse management system. A new system was implemented and has increased stocking efficiency and volunteer productivity, while decreasing material handling.

REDESIGN AND IMPROVEMENT OF HYDRAULIC BIKE FOR CHAINLESS CHALLENGE COMPETITION
by Dan Jasperse, Cory Niemi, and Curtis Stack
Faculty Advisors: Alamgir Choudhury, Pavel Ikonomov, and Betsy Aller
10:30 a.m. to 10:55 a.m., D-201

Increased consumer interest exists in alternative transportation modes, in response to rising fuel costs and environmental awareness. A recumbent bike powered by hydraulics, which previously placed in the Chainless Challenge competition, was modified with the goal of decreasing rider work while increasing energy output. Modifications to increase efficiency included gearing revision, component weight reduction, hydraulic system enhancement, and the addition of an accumulation system. Tools used for these modifications included finite element analysis (FEA) to identify applicable stresses and strains, CAD software for 3-D modeling, and computational fluid dynamics (CFD) software to model the hydraulic system. The redesigned bike will serve as a model for future lighter, more efficient bikes.

TWO WHEELED UPRIGHT HYDRAULIC BICYCLE
by Bryan Colman, Jacob Fowler, Derek Jaromin, Jordan Kimble, and Jared Szklarski
Faculty Advisors: Alamgir Choudhury and Pavel Ikonomov
11:00 a.m. to 11:25 a.m., D-201

Past hydraulic bike teams have done very well using recumbent bike configurations in the previous Chainless Challenge competitions. In order to maintain a competitive edge and continue innovation of hydraulic bicycles, a traditional upright bicycle has been designed, built, and tested. The bicycle was modeled in Pro/Engineer, fabricated, and fitted with a hydraulic drive system. The finished bicycle was tested under simulated course conditions to verify the design. The upright style boasts reduced weight and improved ergonomics, giving this new design the competitive edge in the Chainless Challenge competition.
The current economic situation and a growing emphasis on environmental concerns support the use of sustainable practices in industry. Waste oil from a food manufacturing process was assessed for potential use as a feedstock for biodiesel. Trial samples were converted to usable B-100 fuel meeting ASTM standards, and financial benefits were determined through cost analysis. A bench scale, proof-of-concept processor was developed to support a business case for full-scale implementation.

PREDICTIVE MODELING OF DIGITAL AND PRINT MEDIA
by Robert Cookingham, David Treier, and Melanie Zaleski
Sponsor: Brian Abbot, Western Herald
Faculty Advisor: Bob White
1:00 p.m. to 1:25 p.m., D-201

In this age of digital information, there is a growing demand for print media to make the transition to the internet. Newspapers, especially, must develop a delicate balance between online and print distribution in a cost effective way. Crystal Ball, a program which allows for simulation with variability, was used to develop a predictive model on how the integration of digital media will affect advertising revenues and production costs. This completed analysis will aid in maximizing profit by utilizing a proper balance of digital and print media.

A SEMI-AUTOMATED PROGRAM FOR PART SCHEDULING
by Saeed Sulemana Baba, Yenni Chen, and Wen Ken Loh
Sponsor: Chris McDermott, Denso Manufacturing Michigan, Inc.
Faculty Advisors: Bob White and Azim Houshyar
1:30 p.m. to 2:00 p.m., D-201

Manual scheduling is time consuming and has been deemed non value added in manufacturing. A semi-automated program using Microsoft Excel and VBA was created and used for making scheduling faster and easier. The program would automatically schedule production on specific lines based on the input by the user. Additionally, any constraints or preference related to the characteristics of each part would be taken into consideration when assigning the parts to a production line. By providing such a program, time is saved on scheduling and instead, more time is spent on production; hence this creates a competitive edge.
INSULATED COFFEE CUP DESIGN
by Luke Biltgen and Kyle Eggerstedt
Sponsor: Dennis McCarthy
Faculty Advisor: Ho Sung Lee
9:00 a.m. to 9:25 a.m., D-109

In today’s increasingly environmentally-conscious society, there is a social responsibility for manufacturers to use green materials in their products. Many manufacturers have financed significant research into developing an environmentally-friendly solution to the insulated, disposable coffee cup. A fully biodegradable, disposable coffee cup was designed with improved thermal resistance from that of the current market standard. The prototype was modeled using Solid Works 3-D software, and a working model was constructed.

DEVELOPMENT OF A GASOLINE DIRECT INJECTION FUEL SYSTEM
by Nicholas Haydon, Michael Nienhuis, and Geoff Van Gemert
Faculty Advisor: Claudia Fajardo
9:30 a.m. to 9:55 a.m., D-109

In response to the increase in points awarded for fuel economy during the Formula SAE competition, WMU’s Formula Racing Team has requested a more fuel efficient engine package for implementation in future vehicles. A prototype Gasoline Direct Injection engine was designed around a previously Port Fuel Injected single cylinder motorcycle engine. Several design iterations were developed and analyzed using parametric solid modeling with coupled 1D engine simulation and 3D Computational Fluid Dynamic software. The final design fulfilled the primary requirement of increased fuel economy, as well as several secondary goals.

REDESIGN OF THE M-4 FOR THERMAL EFFICIENCY
by Brian Hemker, Garrett Maybee, and Ryan Koch
Sponsor: Panther Arms
Faculty Advisor: Ho Sung Lee
10:00 a.m. to 10:25 a.m., D-109

The M-4 military assault rifle was redesigned to prevent overheating of the firing mechanism. The current rifle uses a direct impingement system to enable the gun to shoot at a high firing rate with a low amount of kick back. Direct impingement uses part of the bullet exhaust for reloading which results in extreme temperatures, which in turn can lead to a possible misfire. The new design features a short-stroke piston which separates the high temperature gas from the reload chamber of the gun. The new design was tested through analytical calculations, simulation software, and prototyping. The short-stroke piston design eliminated the overheat problem without damaging the gun’s performance.
DRAG REDUCTION OF A CLASS-8 SEMI TRACTOR-TRAILER
by Christopher Heffner and Frederic Smith
Sponsor: Reflex Industries, Inc.
Faculty Advisors: Tianshu Liu and William Liou
10:30 a.m. to 10:55 a.m., D-109

Aerodynamic drag on a class-8 semi tractor-trailer was reduced using a flat tail plate configuration. This reduction was achieved by controlling the air flow attachment on the rear of the trailer to minimize pressure drag caused by flow separation. Wind tunnel tests were performed on a tractor-trailer model to measure the effectiveness of various horizontal tail plate configurations that were attached to the rear of the model; these configurations used variations in length, width, vertical location, and angular orientation in testing. Data analysis demonstrated how these alterations changed overall tail plate effectiveness and revealed the optimal design configuration for drag reduction. Luminescent oil film methods were also utilized for visual representation of flow attachment and separation.

MAGNETIC SHAPE MEMORY ALLOYS FOR ALTERNATIVE ENERGY AND GREEN REFRIGERATION
by Gregory Huizenga and Michael Morris
Faculty Advisor: Pnina Ari-Gur
11:00 a.m. to 11:25 a.m., D-109

Magnetic shape memory (MSM) alloys have potential for many applications including alternative energy and green refrigeration due to their sensitivity to the magneto-caloric effect. The introduction of a magnetic field causes magnetic and structural transitions resulting in large entropy and corresponding temperature changes. Samples of Nickel-Manganese-Indium (NiMnIn) MSM alloys were prepared in an arc melting furnace and heat treated. The samples were then characterized by means of electron microscopy, x-ray diffraction, and neutron scattering. The alloys' magnetization behaviors were measured at various temperatures and magnetic field strengths. The data analysis showed promising properties. These results will be coupled with future research to determine optimal sample composition and preparation to achieve maximum magneto-caloric effect in a room temperature environment with minimal applied magnetic field.
MECHANICAL SHAKE TABLE FOR HYBRID EARTHQUAKE TESTING OF STRUCTURES
by Jonathan Holtz, Justin Poel, and Heather Schmitt
Faculty Advisor: Koorosh Naghshineh
11:30 a.m. to 11:55 a.m., D-109

In order to design structural systems such as bridges and buildings that withstand earthquakes it is necessary to understand the performance of the structural system during an earthquake. A mechanical shake table was designed using Autodesk Inventor software, and was constructed to be used in the seismic testing of small scale prototypes of full-sized structures. Research was conducted into existing shake table systems. A hydraulic control system and data acquisition system were designed to operate the table and to measure displacements, accelerations, and forces in the test structure. The resulting shake table allows simulation of recorded earthquakes at multiple magnitudes, allowing structural seismic research for current and future students and faculty.

STUDY OF CHARACTERISTICS OF HYDROGELS INFUSED WITH MAGNETIC NANOPARTICLES
by Tyler Ondracek, Joseph Mowat, and Doug Ford
Faculty Advisor: Muralidhar Ghantasala
1:00 p.m. to 1:25 p.m., D-109

Ferrogels are gel materials infused with magnetic nanoparticles that have potential applications ranging from sensors and microactuators to targeted drug delivery. In order to implement Ferrogels in these applications it is necessary to understand how they react to their environment. To understand how nanoparticles are distributed in the gel extensive testing was done using USAXS (Ultra Small Angle X-ray Scattering), TEM (Transmission Electron Microscope) and DC-SQUID (Direct Current Superconducting Quantum Interface Device). In addition, an apparatus was designed and built to test the mechanical properties of the Ferrogel. Finally, a computer model was created using COMSOL (FEA software) to simulate the effects of varying environmental pH levels. The data collected has helped to improved Ferrogel fabrication.

AFTERMARKET CNC CONVERSION FOR A BENCH TOP MILLING MACHINE
by Caleb Ihrig
Faculty Advisor: James Kamman
1:30 p.m. to 1:55 p.m., D-109

A low-cost, aftermarket CNC conversion for the bench-top Sieg X3 milling machine was designed and built. The conversion is relatively low-cost and requires little to no modification to the existing machine. It is simple to install and can be implemented in stages, all while maximizing the working envelope of the machine. The mill and conversion parts were modeled in SolidWorks and analyzed using FEA software. Electrical control systems were designed using the PSpice modeling software.
Ankle sprains are a common injury. Conventional treatment of this injury takes such a long period of time that an ankle rarely heals completely. Ankle distraction is a technique for correction of restrictions of the ankle joint. Currently, a doctor must perform this technique within a medical facility which makes the procedure expensive and time consuming. A prototype device was designed, built, and tested that would allow an individual to perform ankle distraction outside of a medical facility. The new design includes a larger range of fit and is easier to use than prior designs. The materials were chosen based on safety, comfort, cost, and manufacturability. Finally, the device was tested to ensure that the given parameters were satisfied.

Currently, the dune buggy industry is relying on old, outdated, air cooled engines to power the majority of dune buggies. There is demand for an engine with improved power and performance. The small block V-8 engines, popular in racing, can provide ample power for nearly anyone, as they can be customized with aftermarket parts to meet individual owner demands. Considering the substantial weight increase over the air-cooled engine, a mid-engine configuration vehicle was designed to accommodate the change. The optimized dune buggy frame was designed using solid modeling software and verified using finite element analysis software.
COATING FOR IMPROVING SMOOTHNESS OF NCSU NON-WOVEN TEXTILE
by Margaret Gerhart
Faculty Advisor: Margaret Joyce
9:00 a.m. to 9:25 a.m., D-208

Non-woven textiles are used in medical applications where tough, stain resistant garments are needed. The incorporation of electronic devices into these garments to monitor patient vital signs is being explored. Printed electronics would enable this to be done inexpensively, but previous attempts have shown the roughness of these materials to be too high to produce a functional electronic device. This work explored the application of a barrier coating which would provide the needed smoothness without calendaring.

PHOTOCATALYTIC PAPER AND COATING STUDY FOR THE DEGRADATION OF TOXINS
by Kelsey Dykstra
Faculty Advisor: Margaret Joyce
9:30 a.m. to 9:55 a.m., D-208

Photocatalytic paper is a specific category of paper which has the capability to degrade and decompose toxins resulting in a health conscience paper product. This paper may be used for food packaging, wall paper, and paper for particle board along with other applications. A titanium dioxide – natural zeolite coating with different binders were applied to photocatalytic paper provided by Nippon and a commercial non-photocatalytic paper. Toxin degradation was measured using a photoreactor with UV source followed by gas chromatography. The results of this may result in a more health conscience paper.
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