RESEARCH ESSAY

Listed below are a number of topics that are currently of interest in the engineering world. Each short description indicates the issue, identifies the areas of engineering that are involved, and offers a starting reference.

Each student is to write a 3-5 page research essay on one of the topics. The essay should cover the following points and should be based on at least two additional non-Web references:

A. Overview of the problem/application
B. Technological challenges
C. Review of current technology
D. Discussion of emerging technology
E. Technology hope for the future

Students should sign up for their choice of a topic. No more than three students per topic. First come; first served.

Note: Reference URLs are provided as a starting point for your research. However, since this assignment was generated several years ago, some of the links may no longer be valid. You should have no trouble finding others.

1. Thermoacoustic heating/refrigeration—When a gaseous medium is compressed its temperature goes up; when it is expanded its temperature goes down. Since sound consists of waves of expansion and contraction it is possible to exploit acoustic waves as motorless heaters or refrigerators. Development of systems is currently underway. [Mechanical engineering.] Ref: Swift, Gregory W., “Thermoacoustic Engines and Refrigerators”, Physics Today, July, 1995, pp. 22-28.

2. Nanomachines—Molecular manufacturing, nanometer-scale robots and computers, are goals of nanotechnology. Can we develop devices that can manipulate molecules one atom at a time? The possible uses are staggering: from DNA repair to computers with the capacity of the human brain. There is a Feynman Grand Prize for the first person (lab) that can build a nano-robot and a nano-calculator which fulfil a set of specifications. [Chemical engineering; materials science.] Ref: Drexler, K. Eric, *Engines of Creation*

3. Noise cancellation—Since sound is a traveling pressure wave, it is possible to cancel the sound from source A with an exactly out-of-phase sound from source B. If A is the offending sound, a fast computer can sample A, then calculate and produce the “anti-sound” to cancel the sound from A. This technique is being explored to replace car mufflers (for increased fuel efficiency), and to provide sound attenuation for people in noisy environments (heavy industry, commercial airliners). [Mechanical engineering]. Ref: http://www.engg.ksu.edu/KSE/spring96/sound/sound.html.

4. Robots—machines to handle hazardous materials, to explore Mars, to perform intricate medical operations, to manufacture and assemble goods. Robots that can move, manipulate, and sense are increasingly being used in everyday society. But technological problems exist in multi-axis mechanical motions, feedback control, and motion-control algorithms. [Mechanical engineering.]
Ref: http://www.frc.ri.cmu.edu/robotics-faq/4.html.

5. Transdermal drug delivery—An objective of drug delivery mechanisms is to produce a concentration of drug in the body which remains in the "effective" range over a long period of time. Pills or injections produce concentrations which decrease over time: first the concentrations are too high, then they pass through the effective range, then they drift lower to become ineffective. The solution to the problem is to deliver drugs continuously at an optimum rate. One mechanism for doing this is to impregnate a porous polymer patch with medication, attach the patch to the skin, and allow the drug to diffuse continuously through the skin into the body. Nicotine and motion-sickness patches are on the market today. [Biomedical, chemical engineering.] Ref:
http://www.pharmacy.umaryland.edu/~rdalby/Pceutics/Transdermal/sld001.htm .

6. Composite-material structures-bridges—Bridges that don't rust or that monitor their own behavior are possible with composite materials. Bridges made of carbon fibers and polymers are perhaps the wave of the future. And, with the decaying of the U.S. transportation infrastructure, a lot of new bridges will be built in the next several decades.
[Civil, mechanical engineering; materials science.] Ref:
http://www.tfhrc.gov/structur/bridge/strcc.htm.

7. Medicine at a distance—What are the possibilities? Remotely-performed liver transplants? EKG's monitored from another city? Neurological exams stored on CD-ROM? What are the problems? Some are technological: reliable, high-speed, two-way communication; remote-controlled instruments; technology too complicated. Some are cultural: redefines the relationship between physician and patient; legal and ethical issues. [Biomedical, mechanical, electrical engineering.]
Ref: http://tie.telemed.org/news/.

8. Digital communication—28.8K, ISDN, T-1, ATM, DSL, Internet 2. These are all buzzwords related to digital data transmission. How will we be communicating in the next 5 years? 10 years? What are the technologies, the costs, the infrastructure requirements? What's on the horizon with respect to error detection/correction and reliability? This is where it's at in electrical engineering. [Computer science; electrical, computer engineering.] Ref:
http://www.it.kth.se/edu/gru/Telesys/96P3_Telesystem/HTML/Module5/Physical-8.html
http://www.gofordsl.com/dsl.htm .

9. Digital video compression—Inexpensive transmission of high-quality video is the holy grail of communication systems. It will be carried out in part by higher-speed, time-sensitive communication networks, in part by progressively more-sophisticated video

compression algorithms, and in part by faster video processors. HDTV, MPEG1, MPEG2, satellite digital video. What is all this? Where is it going? [Computer science; electrical, computer engineering.]
Ref: http://www.rcc.ryerson.ca/schools/rta/brd038/papers/1996/mpeg1.htm.

10. High-speed trains—The TGV, the high-speed French train, is being reengineered for speeds higher than its current 350km/hr operating rate. The problem is that, as the train enters a tunnel, air in the tunnel must be displace in a way that does not buffet the train. Other aerodynamic problems exist as well. This problem will also be encountered as the Swiss develop their maglev train system. [Mechanical, civil engineering.] Ref: TGV Research, http://mercurio.iet.unipi.it/tgv/research.html.

11. Toxic waste containment/disposal—The encroachment of toxic chemicals into underground aquifers is of grave concern. If heavy metals and radioactive wastes enter these sources of our water supply, whole regions of the U.S. could become uninhabitable. Predicting and/or preventing this occurrence is a difficult problem. [Mechanical, civil, environmental engineering; mathematical sciences.] Ref: Physics Today, June 1997, Special Issue: Radioactive Waste.

12. Earthquake-resistant structures—What happens when a massive structure is shaken—as in an earthquake? Unfortunately, the answer is typically: devastation. But, if the characteristics of potential tremors are partially predictable, it is possible to design structures which can withstand them. Floating foundations, feedback-controlled weights, flexible structures, are techniques which need further development. Remember, San Francisco is still waiting for “the big one”. [Civil, mechanical engineering.]

13. Battery technology—plastic batteries? They’re currently under development at JHU. But there are many other technologies as well. Development focuses on energy density, weight, cost, rechargability, life expectancy, and toxicity. Electrical storage is a necessity and batteries are the medium of choice for many applications. [Chemical engineering; materials science.] Ref: http://www.solardome.com/SolarDome60.html.

14. Solar electricity—From corrosion protection to lighting navigation buoys, solar power is the energy source of choice for many applications. The trouble is that with current technology, solar energy conversion is relatively inefficient. With improvements in the design of photovoltaic cells, an astonishing number of new applications would become economically possible. [Materials science.]
Ref: http://www.solardome.com/SolarDome4.html.

15. Increased power of computers—Moore’s Law states that every 18 months computer power doubles. Where does this increase in computer power come from? What’s the long term prognosis for this “law”? Will IBM’s new copper-based chip technology contribute? If Moore’s law holds into the 2020’s, computers could have the “intelligence” of the human brain. [Computer science; computer engineering.]
Ref: http://www.intel.com/intel/museum/25anniv/hof/moore.htm.

16. Smart materials—You've surely seen an eyeglass lens that darkens in sunlight. That's a smart material. What about a material that could serve as the skin on an airplane wing that could sense local pressure disturbances and mechanically react to avoid stall? What about a material that could react to vibration by increasing its stiffness and thereby reduce the vibration? These are goals of smart material efforts. [Chemical engineering; materials science.] Ref: Amato, Ivan, "Animating the Material World", Science, Jan 17, 1992, pp. 284-286.