Engineering:

From your mind!
through your heart(?)

Mark J. McCready

Professor of Chemical and Biomolecular Engineering

Senior Associate Dean for Research and Graduate Studies

College of Engineering

http://www.chemeprof.com/

Outline

- Provide some insight into what "engineering" is as a profession and as an academic major
- Raise some issues that you may want to consider as you are deciding what to do in your future
  - Will you find personal fulfillment as an engineer?
- I will take a rather abstract approach
  - Different academic disciplines of engineering have varying degrees of

WHY ALL OF THIS IS IMPORTANT!

Volkswagen to Pay Up to $14.7 Billion to Settle Diesel-Emissions Claims

The settlement comprises vehicle buybacks or fixes

Volkswagen has settled emissions claims with regulators and owners of about a half million diesel-powered vehicles. The settlement terms were announced Tuesday by environmental regulators. The WSJ's Lee Hawkins explains.

What is Engineering?

- Ok, so it is claimed that engineers can make the world better....
- HOW... do they do it?

Definitions of engineering

en·gi·neer [en-*juh*-**neer**] Show IPA *Dictionary.com Unabridged*

noun

1. a person trained and skilled in the design, construction, and use of engines or machines, or in any of various branches of engineering: *a mechanical engineer; a civil engineer.*

engineering Use Engineering in a sentence Like

en·gi·neer·ing [en-*juh*-**neer**-ing] Show IPA

noun

1. the art or science of making practical application of the knowledge of pure sciences, as physics or chemistry, as in the construction of engines, bridges, buildings, mines, ships, and chemical plants.
2. the action, work, or profession of an engineer.
3. skillful or artful contrivance; maneuvering.

Origin:
1710–20; engineer + -ing[1]

en·gi·neer·ing
/ˌenjəˈni(ə)riNG/

noun
noun: **engineering**

the branch of science and technology concerned with the design, building, and use of engines, machines, and structures.

- the work done by, or the occupation of, an engineer.
- the action of working artfully to bring something about.
  "if not for Keegan's shrewd engineering, the election would have been lost"

en·gi·neer
/ˌenjəˈni(ə)r/

verb
gerund or present participle: **engineering**

design and build (a machine or structure).
"the men who engineered the tunnel"

- skillfully or artfully arrange for (an event or situation) to occur.
  "she engineered another meeting with him"
  synonyms: bring about, arrange, pull off, bring off, contrive, maneuver, manipulate, negotiate, organize, orchestrate, choreograph, mount, stage, mastermind, originate, manage, stage-manage, coordinate, control, superintend, direct, conduct; More
- modify (an organism) by manipulating its genetic material.
  "genetically engineered plants"

en·gi·neer·ing ***noun*** \-'nir-iŋ\

: the work of designing and creating large structures (such as roads and bridges) or new products or systems by using scientific methods

: the control or direction of something (such as behavior)

Full Definition of ENGINEERING Cite! g+1 Like

1 : the activities or function of an engineer

2 a : the application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to people

b : the design and manufacture of complex products <software *engineering*>

3 : calculated manipulation or direction (as of behavior) <social *engineering*> — compare GENETIC ENGINEERING

See engineering defined for English-language learners »
See engineering defined for kids »

http://www.thefreedictionary.com/

What do engineers do?

- Or, you may have heard it stated that "engineers solve problems..."
- What engineers really do is:
- *Engineers understand how to use techniques of engineering analysis to design (i. e., synthesize) substances, devices and processes even though they have an imperfect understanding of important physical, chemical or biological issues. Furthermore engineers operate under constraints caused by a need to produce a product or service that is timely, competitive, reliable, and consistent with the philosophy and within the financial means of their company.*
- *We need to use all that we know to produce the best answer to a problem!!*

Underlined words

- 1. Engineering analysis

- Engineers use "mathematical models" to describe reality in sufficient detail to produce quantitative results.

- (It is not engineering until we produce some numbers!!)

Underlined words

- 2. Imperfect understanding

- Most significant engineering problems cannot be analyzed and solved exactly.

-

- Thus we need our models or our understanding of phenomena gained by experiment to capture the important features and (usually) ignore a lot of unessential detail.

Curveball vs. knuckle ball

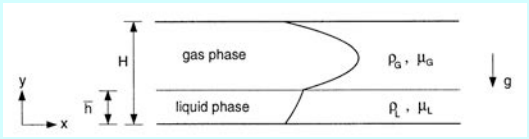
- We tried to make the argument that the imperfectness of a baseball is important to the pitching of a knuckleball, which does not spin and not important in the pitching of a curveball which spins fast. The same effect can either be important or incidental. This is because important issues always as ratios between competing effects. Engineers need to make the decision about what is important!!

Mathematical Analysis

- We would like to know how a device, process or system behaves "before" we build it
  - The only way that this is possible is with accurate mathematical "models" (collections of mathematical equations, that could be based on physical laws or verified observations that represent **reality** sufficiently well)

Mathematical modeling can be complex

Geometry of interest



We will look at the linear stability problem for

- Steady flow
-
- Purely Oscillatory (Couette flow)

Gas-liquid flow interfacial stability problem

turbulence model: k-ε

Solve the base state with either a smooth or rough interface (try to match data).

then

Solve the differential stability problem the best we can

Liquid-phase: $0 \le y^* \le d_1$

$$\rho_1\left[\frac{\partial u_i^*}{\partial t^*}+u_j^*\frac{\partial u_i^*}{\partial x_j^*}\right]=-\frac{\partial p^*}{\partial x_i^*}+\rho_1 g^*\sin(\theta)+\frac{\partial}{\partial x_j^*}\left[(\mu_1+\mu_t^*)(2s_{ij}^*)\right]$$

$$\rho_1\left[\frac{\partial k^*}{\partial t^*}+u_i^*\frac{\partial k^*}{\partial x_i^*}\right]=\frac{\partial}{\partial x_i^*}\left[\left(\mu_1+\frac{\mu_t^*}{\sigma_{ke}^*}\right)\left(\frac{\partial k^*}{\partial x_i^*}\right)\right]+\mu_t^*(2s_{ij}^*)\frac{\partial u_i^*}{\partial x_j^*}-\rho_1\varepsilon^*-2\mu_1\left(\frac{\partial\sqrt{k^*}}{\partial x_i^*}\right)^2$$

$$\rho_1\left[\frac{\partial \varepsilon^*}{\partial t^*}+u_i^*\frac{\partial \varepsilon^*}{\partial x_i^*}\right]=\frac{\partial}{\partial x_i^*}\left[\left(\mu_1+\frac{\mu_t^*}{\sigma_\varepsilon^*}\right)\left(\frac{\partial \varepsilon^*}{\partial x_i^*}\right)\right]+c_1 f_1\mu_t^*\frac{\varepsilon^*}{k^*}(2s_{ij}^*)\frac{\partial u_i^*}{\partial x_j^*}+2\mu_1\mu_t^*\left(\frac{\partial^2 u_i^*}{\partial x_j^*\partial x_i^*}\right)^2-\rho_1 c_1 f_1\frac{\varepsilon^{*2}}{k^*}$$

Stability equations continued

Gas-phase: $d_1 \le y^* \le d_1+d_2$

$$\rho_2\left[\frac{\partial u_i^*}{\partial t^*}+u_j^*\frac{\partial u_i^*}{\partial x_j^*}\right]=-\frac{\partial p^*}{\partial x_i^*}+\rho_2 g^*\sin(\theta)+\frac{\partial}{\partial x_j^*}\left[(\mu_2+\mu_t^*)(2s_{ij}^*)\right]$$

$$\rho_2\left[\frac{\partial k^*}{\partial t^*}+u_i^*\frac{\partial k^*}{\partial x_i^*}\right]=\frac{\partial}{\partial x_i^*}\left[\left(\mu_2+\frac{\mu_t^*}{\sigma_{ke}^*}\right)\left(\frac{\partial k^*}{\partial x_i^*}\right)\right]+\mu_t^*(2s_{ij}^*)\frac{\partial u_i^*}{\partial x_j^*}-\rho_2\varepsilon^*-2\mu_2\left(\frac{\partial\sqrt{k^*}}{\partial x_i^*}\right)^2$$

$$\rho_2\left[\frac{\partial \varepsilon^*}{\partial t^*}+u_i^*\frac{\partial \varepsilon^*}{\partial x_i^*}\right]=\frac{\partial}{\partial x_i^*}\left[\left(\mu_2+\frac{\mu_t^*}{\sigma_\varepsilon^*}\right)\left(\frac{\partial \varepsilon^*}{\partial x_i^*}\right)\right]+c_1 f_1\mu_t^*\frac{\varepsilon^*}{k^*}(2s_{ij}^*)\frac{\partial u_i^*}{\partial x_j^*}+2\mu_2\mu_t^*\left(\frac{\partial^2 u_i^*}{\partial x_j^*\partial x_i^*}\right)^2-\rho_2 c_1 f_1\frac{\varepsilon^{*2}}{k^*}$$

Stability equations continued

k=1 (liquid-phase) $0 \le y \le 1$

k=2 (gas-phase) $1 \le y \le n_2+1$

$$\frac{(\hat{f}_k u'_{b,k})''}{m_k}+\left(\Gamma_{b,k}\hat{\phi}_k'\right)''-2\alpha^2\left(\Gamma_{b,k}\hat{\phi}_k'\right)+\alpha^4\Gamma_{b,k}\hat{\phi}_k=i\alpha R\frac{r_k}{m_k}\left\{\left(u_{b,k}-c\right)\left(\hat{\phi}_k''-\alpha^2\hat{\phi}_k\right)-u''_{b,k}\hat{\phi}_k\right\}$$

$$\frac{(\hat{f}_k k'_{b,k})'}{m_k}+\frac{\hat{f}_k u''_{b,k}}{m_k}+\Gamma_{b,k}\left(\hat{k}_k'-\alpha^2\hat{k}_k\right)+\Gamma_{b,k}\hat{k}_k+2\frac{\hat{f}_k u'_{b,k}}{m_k}\left(\hat{\phi}_k'+\alpha^2\hat{\phi}_k\right)+\frac{k'_{b,k}}{k_{b,k}}\left(\frac{k'_{b,k}}{2k_{b,k}}\hat{k}_k-\hat{k}_k'\right)$$
$$=i\alpha R\frac{r_k}{m_k}\left\{\left(u_{b,k}-c\right)\hat{k}_k-k_{b,k}\hat{\phi}_k\right\}$$

$$\frac{(\hat{f}_k\varepsilon'_{b,k})}{m_k}+\Gamma_{b,k}\Gamma_{b,k}\left(\hat{\phi}_k'-\alpha^2\hat{\phi}_k\right)+\Gamma'_{b,k}\hat{\phi}_k+2c_1 f_1\frac{\hat{f}_k u'_{b,k}}{m_k}\left(\hat{\phi}_k'+\alpha^2\hat{\phi}_k\right)+r_1 Re_2 f_2\frac{\varepsilon_{b,k}}{k_{b,k}}\left(\frac{\varepsilon_{b,k}}{k_{b,k}}\hat{k}_k-2\hat{\phi}_k\right)$$
$$+\frac{\left(u'_{b,k}\right)^2}{m_k}\left[c_1 f_1\frac{\varepsilon_{b,k}}{k_{b,k}}\left(\hat{f}_k+\hat{\phi}_k-\frac{m_k\mu_{b,k}}{k_{b,k}}\hat{k}_k\right)+\frac{2m_k}{r_1 R}\left(\hat{f}_k+2\mu_{b,k}\hat{\phi}_k'\right)\right]$$
$$=i\alpha R\frac{r_k}{m_k}\left\{\left(u_{b,k}-c\right)\hat{\varepsilon}_k-\varepsilon_{b,k}\hat{\phi}_k\right\}$$

$$\hat{f}_k=c_{\mu,k}f_k r_k R\frac{k_{b,k}}{\varepsilon_{b,k}}\left(2\hat{k}_k-\frac{k_{b,k}}{\varepsilon_{b,k}}\hat{\varepsilon}_k\right)$$

Stability Equations cont.

Boundary conditions

$$\hat{\phi}_1=\hat{\phi}_2 \qquad (3\text{-}18c)$$

$$\hat{\phi}_1'+u_{b,1}'\hat{h}=c\hat{h} \qquad (3\text{-}18d)$$

$$\hat{\phi}_1'-\hat{\phi}_2'=\hat{h}\left(u'_{b,1}-u'_{b,2}\right) \qquad (3\text{-}18e)$$

$$\hat{\phi}_1''+\alpha^2\hat{\phi}_1+\hat{h}u''_{b,1}=m_2\left(\hat{\phi}_2''+\alpha^2\hat{\phi}_2+\hat{h}u''_{b,2}\right) \qquad (3\text{-}18f)$$

$$\left(\hat{\phi}_1'''+\Gamma'_{b,1}\hat{\phi}_1''+u'_{b,1}\hat{f}_1'-3\alpha^2\hat{\phi}_1'\right)+i\alpha R\left(u'_{b,1}\hat{\phi}_1-u_{b,1}\hat{\phi}_1'\right)-m_2\left(\hat{\phi}_2'''+\Gamma'_{b,2}\hat{\phi}_2''+u'_{b,2}\hat{f}_2'-3\alpha^2\hat{\phi}_2'\right)$$
$$-i\alpha r_2 R\left(u'_{b,2}\phi_2-u_{b,2}\phi_2'\right)-i\alpha R\left[(1-r_2)F+\alpha^2 S\right]\hat{h}=i\alpha Re\left(r_2\hat{\phi}_2'-\hat{\phi}_1'\right) \qquad (3\text{-}18g)$$

$$\hat{k}_1=\hat{\varepsilon}_1=\hat{f}_1=\hat{k}_2=\hat{\varepsilon}_2=\hat{f}_2=0 \qquad (3\text{-}18h)$$

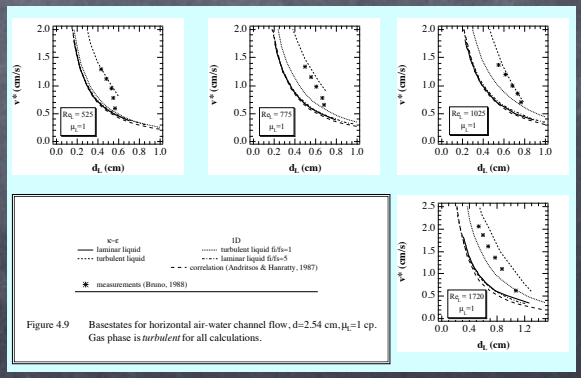


Figure 4.9 Basestates for horizontal air-water channel flow, d=2.54 cm, μ_L=1 cp. Gas phase is *turbulent* for all calculations.

Mathematical analysis

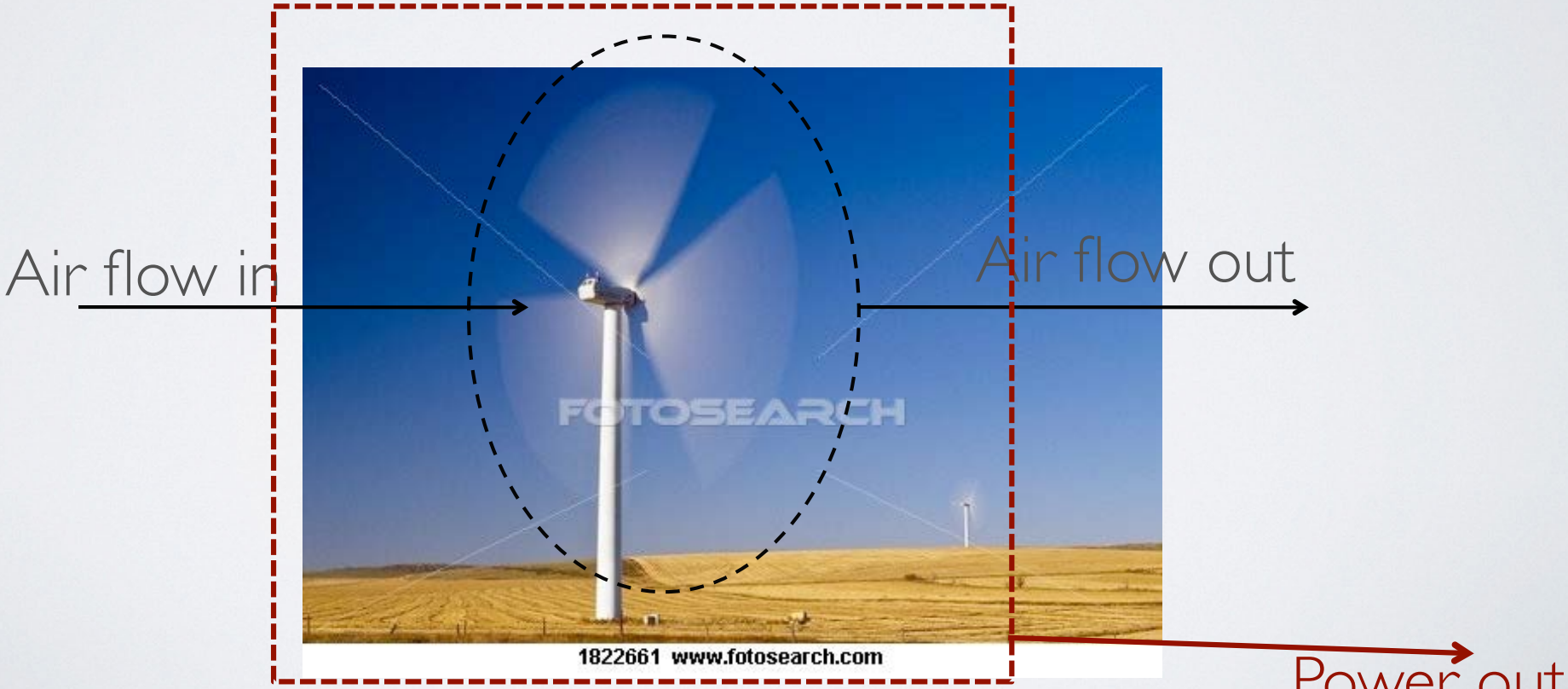
- Could be pretty simple:
- What if we read the Wall Street Journal
  - Wind power
  - http://online.wsj.com/article/SB10001424127887324310104578507242336481504.html?KEYWORDS=wind+energy

Engineers like to compare things

- If I asked: ".. how far is it to Chicago?"
  - would you answer?
    - "a couple of hours" or...
    - "about 90 miles"
- If I asked: ".. is a meter a long distance?" what would you say
  - "No", compared to the distance to Chicago
  - "Yes", compared to a micron
- For our conclusion to be valid we need to
  - **compare** like (same dimensions) quantities.

POWER AND WIND SPEED?

- How does the power generated by the windmill change with wind speed?
  - How is power being generated?
    - Wind flows through area swept by blades
    - Windmill converts this kinetic energy to electric power



POWER AND WIND SPEED?

- How does the power generated by the windmill change with wind speed?
  - Let's see if we can figure this out based on dimensional reasoning
    - Power is work/time which is force * distance/time which is mass* acceleration *distance/time
    - Thus we could write

$$power = m\ l / t^2 l / t = \frac{ml^2}{t^3}$$

    - What variables could be used?

EQUATION FOR POWER FROM WIND

- Windspeed, blade diameter, air density
  - v [=] l/t
  - d, r [=] l
  - Density of air ρ [=] m/l^3
  - Arrange these variables to get dimensions of power:

$$power \sim \rho v^3 d^2 [=] \frac{ml^2}{t^3}$$

  - If the wind speed doubles, the power increases by a factor of 8!

Engineering

- Engineers seek to develop technologies that make the world a better place for humanity!
  - There are elements of creativity involved
- However, we need to realize there are limitations…
  - The laws of nature!

Physical Laws

$$\mathbf{F} = \frac{\mathrm{d}\mathbf{p}}{\mathrm{d}t} = \frac{\mathrm{d}(m\mathbf{v})}{\mathrm{d}t}.$$

he second law can also be stat

$$\Delta U = Q + W$$

$$\mathrm{d}S > \frac{\delta Q}{T}$$

Differential equations

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{B} = \mu_0\left(\mathbf{J} + \varepsilon_0\frac{\partial \mathbf{E}}{\partial t}\right)$$

Incompressible Navier–Stokes equations (*convective form*)

$$\frac{\partial \mathbf{u}}{\partial t} + (\mathbf{u} \cdot \nabla)\mathbf{u} - \nu\nabla^2\mathbf{u} = -\nabla w + \mathbf{g}.$$

Deflection at Any Given Point

$$y = \frac{Wx(l-x)}{24EIl}[l^2 + x(l-x)]$$

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Majoring in Engineering at a University

- In the spirit of "truth in advertising", "Engineering" as a college major is an intense intellectual experience.
- Engineers need to provide the exact design specifications for all of the technologies.
- Hence we spend a lot of time teaching you how to do calculations and to get the numbers correct
  - Professors give "lectures" about what you need to understand
    - Some of the topics are completely new!
- You go off and read, do homework (usually with your friends) and "study".
- We then have a "test" to find out how much you learned!

Do we already know everything?

- You might say...
  - "Maybe there is little that I could contribute."
- Over the years, many claims of certainty have proven to be completely wrong!

It is OK to challenge accepted thinking!

- Some things we thought we knew:
  - Margarine was considered a health food
  - Left-handed people die sooner because of the hazards of the right-handed word
  - Stomach Ulcers are caused by stress
  - Plants absorb CO2 and emit O2
  - The adult brain has no capacity to regenerate itself
  - Komodo Dragons bit their prey and waited for them to succumb to bacterial infections

SOME DOUBT BUT…

The Diet-Heart Myth: Cholesterol and Saturated Fat Are Not the Enemy

on APRIL 19, 2013 *by* CHRIS KRESSER 619 *comments*

How did we come to believe saturated fat and cholesterol are bad for us?

17 JUL

325

CHOLESTEROL IS NOT BAD FOR YOU

Home > Blog > Cholesterol is not bad for you

Published on: Wednesday, 27 May, 2015

A sixty-year torrent of bad dietary advice is coming to an end

My Times column on the U-turn over cholesterol and saturated fat:

Cholesterol U-turn as research shows fatty foods might not be bad for us after all

Doctors are now focusing on sugar as the biggest danger to public health

SOME DOUBT?

The U.S. government is poised to withdraw longstanding warnings about cholesterol

By **Peter Whoriskey** February 10, 2015

Time to put eggs back on the menu? (Deb Lindsey for The Washington Post)

Most Read

1. The world's losers are revolting, and Brexit is only the beginning 
2. The British are frantically Googling what the E.U. is, hours after voting to leave it 
3. Brexit is a reminder that some things just shouldn't be decided by referendum 
4. California may have a huge groundwater reserve that nobody knew about 
5. Ginsburg smacks down a major abortion myth after historic SCOTUS ruling 

LOW FAT?

Four reasons "fat-free" isn't good for you

on MARCH 18, 2013 *by* LIFE WITH GREENS *in* MISLEADING MONDAYS 27

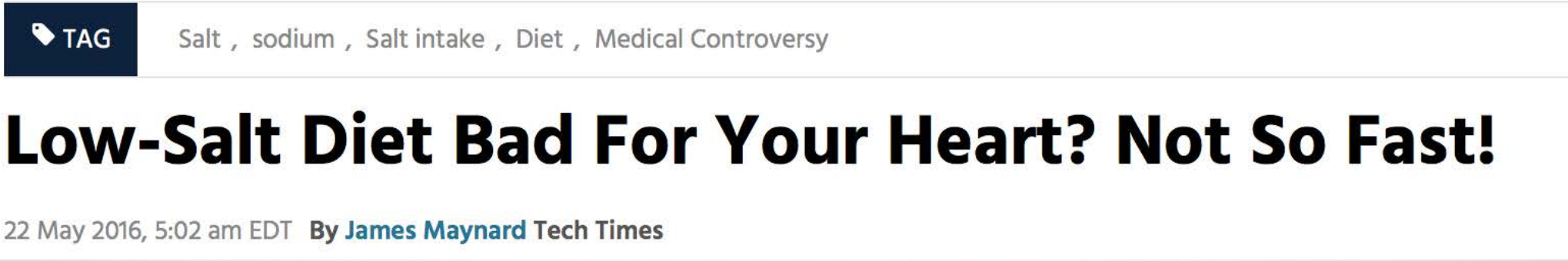
The truth about low-fat foods

Kerry Torrens

Low fat foods stuffed with 'harmful' levels of sugar

SALT?


Go to Well Home
Well
HEART
A Low-Salt Diet May Be Bad for the Heart
By NICHOLAS BAKALAR MAY 25, 2016 1:45 PM 69


TAG
Salt , sodium , Salt intake , Diet , Medical Controversy
Low-Salt Diet Bad For Your Heart? Not So Fast!
22 May 2016, 5:02 am EDT By James Maynard Tech Times

FOR SURE?

MAY 19, 2015 @ 09:53 AM 992,220 VIEWS

The Little Black Book of Billionaire Secre

Updated NASA Data: Global Warming Not Causing Any Polar Ice Retreat

James Taylor, CONTRIBUTOR

I write about energy and environment issues. **FULL BIO**

Opinions expressed by Forbes Contributors are their own.

Updated data from NASA satellite instruments reveal the Earth's polar ice caps have

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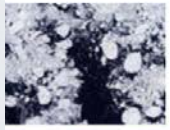
NASA's Operation IceBridge Completes 2016 Arctic Spring...

22 days ago



Clouds and Sea Ice: What Satellites Show About Arctic Climate Change

25 days ago

NASA Studies Details of a Greening Arctic

Ice

Oct. 30, 2015

NASA Study: Mass Gains of Antarctic Ice Sheet Greater than Losses

A new NASA study says that an increase in Antarctic snow accumulation that began 10,000 years ago is currently adding enough ice to the continent to outweigh the increased losses from its thinning glaciers.

MUCH OF WHAT IS BEING PUBLISHED IS PROBABLY NOT CORRECT!

Essay

Why Most Published Research Findings Are False

John P. A. Ioannidis

Over half of psychology studies fail reproducibility test

Largest replication study to date casts doubt on many published positive results.

Monya Baker

ESSAY

Why Most Clinical Research Is Not Useful

John P. A. Ioannidis[1,2]*

Studies show only 10% of published science articles are reproducible. What is happening?

Posted on May 3, 2012 by Moshe Pritsker

Studies show a very low reproducibility for articles published in scientific journals, often as low as 10-30%. Here is a partial list:

EVEN THE TEMPERATURE? (YIKES!)

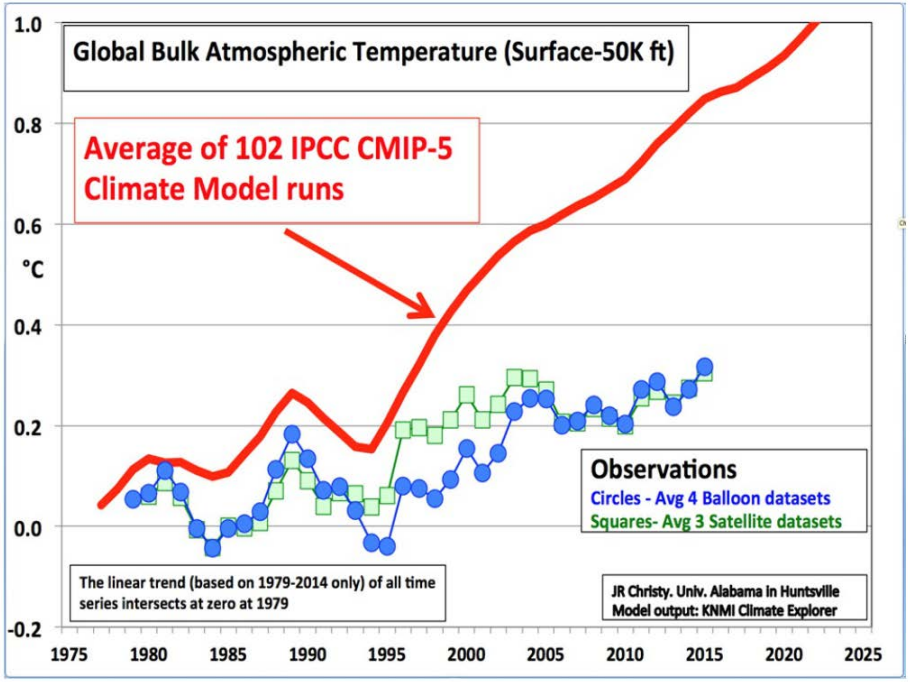
Earth is warming 50x faster than when it comes out of an ice age

A major new study includes some scary implications about how rapidly humans are changing the Earth's climate

THE DAILY CALLER NEWS FOUNDATION

Scientists Finally Admit Climate Models Are Failing To Predict Global Warming

Committee of the U.S. House of Representatives on December 8.



HAEL BASTASCH

10:19 AM 02/26/2016

WE NEED YOU!

- Desperately!

Significant Progress

- Gas mileage doubled since 1972

Significant Progress

- Fuel use per passenger mile is about 30% of original passenger jets

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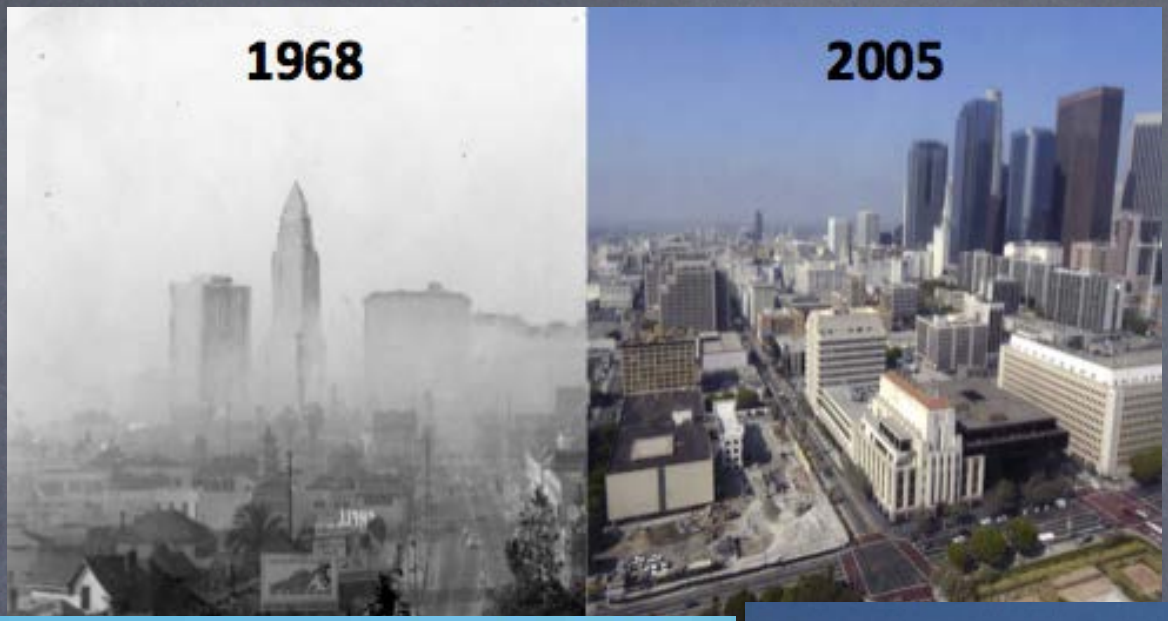
Success to date



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Some thoughts

- You will (soon) actually be in a position to make decisions on your own
  - some of which will determine your future path!
- It is possible that the issue of fulfillment is a bit complex:
  - You may have had discussions with your friends, and with yourself along the lines...
    - Should I try to make a lot of money?
    - Should I try to "save the world"?

How to resolve this dilemma

- (I promised "abstract" so here goes….)
- Some of our chemical engineering students are in London and I was there last week…

London 2016

http://www.chemeprof.com/

Summer 2014…

/www.chemeprof.com/

Some quotes falsely attributed to Winston Churchill

- "If you are not a liberal when you are 25 you have no heart. If you are not a conservative when you are 35, you have no brain!"
- "You make a living by what you get; you make a life by what you give!"
- Heart/mind conflict:
- How does engineering fit in?

Major issues for Humanity

- Healthcare
- Energy
- The Environment
- The Economy
- Engineers are critically involved in all of these and will chart the future course
- "Society" may call these issues "problems", engineers see these as challenges to be met!

RECAP

- Engineering involves analyzing a specific device or system using mathematical analysis based on physical laws or empirical understanding
- All problems of real importance have some degree of uncertainty and so judgement is needed
- Many big questions remain and you can contribute to their solution
- You may find fulfillment in the problems of global importance that are being addressed by engineers!

Dimensionless Confucius Proverb

$$Cr \equiv \frac{How\ \ Smart\ \ You\ Are}{How\ \ Smart\ \ You\ \ Think\ \ You\ \ Are}$$

- He who knows not and knows he knows not is a child, teach him, Cr~1
- He who knows not and knows not he knows not is a fool, shun him, Cr<<1
- He who knows and knows not he knows is asleep, awaken him, Cr>>1
- He who knows and knows he knows is wise, follow him Cr~1

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