Accelerated Cooling -- a Forensics Physics Issue

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Disclaimer

The opinions expressed do **not** represent

any official position by Boise State University.

Ultra-sensitive social issue

- Deaths of infants
- Possibly murder
- Justice or compounded tragedy?
- Political maneuvering?
- Medical art *versus* science
- Authoritarianism
- Junk science

Taboo subject

Nothing hurts as much as the death of a child.

“Sir, you do not know our pain.”

Vengeance is a powerful motivator.

Warning (Deu 32:35 Psa 94:1 Rom 12:19 Heb 10:30)

Millstone curse? (Matt 18:6 Mar 9:42 Luk 17:2)

We are quick to condemn and even crucify.

World Views?

Good intentions?

Aspiring demigods?

Physics must transcend these issues!

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What are the observables?

What can be measured?

Examine the facts.

William Thompson → Lord Kelvin (1824-1907)

" I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of Science, whatever the matter may be."

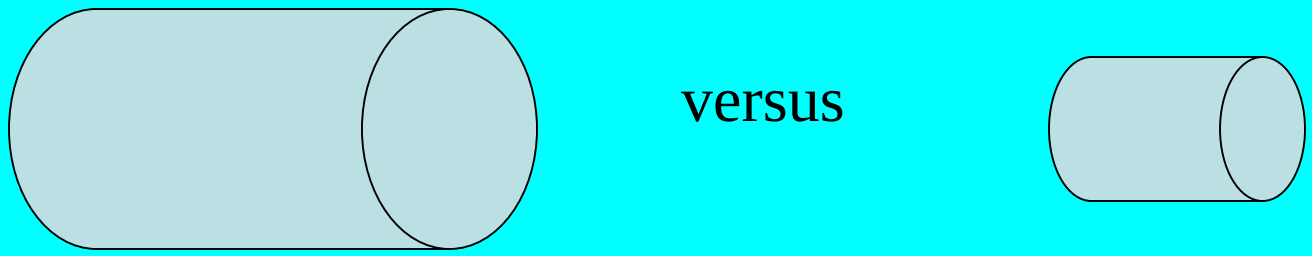
Experimental physics relies on the authority of reproducible measurements

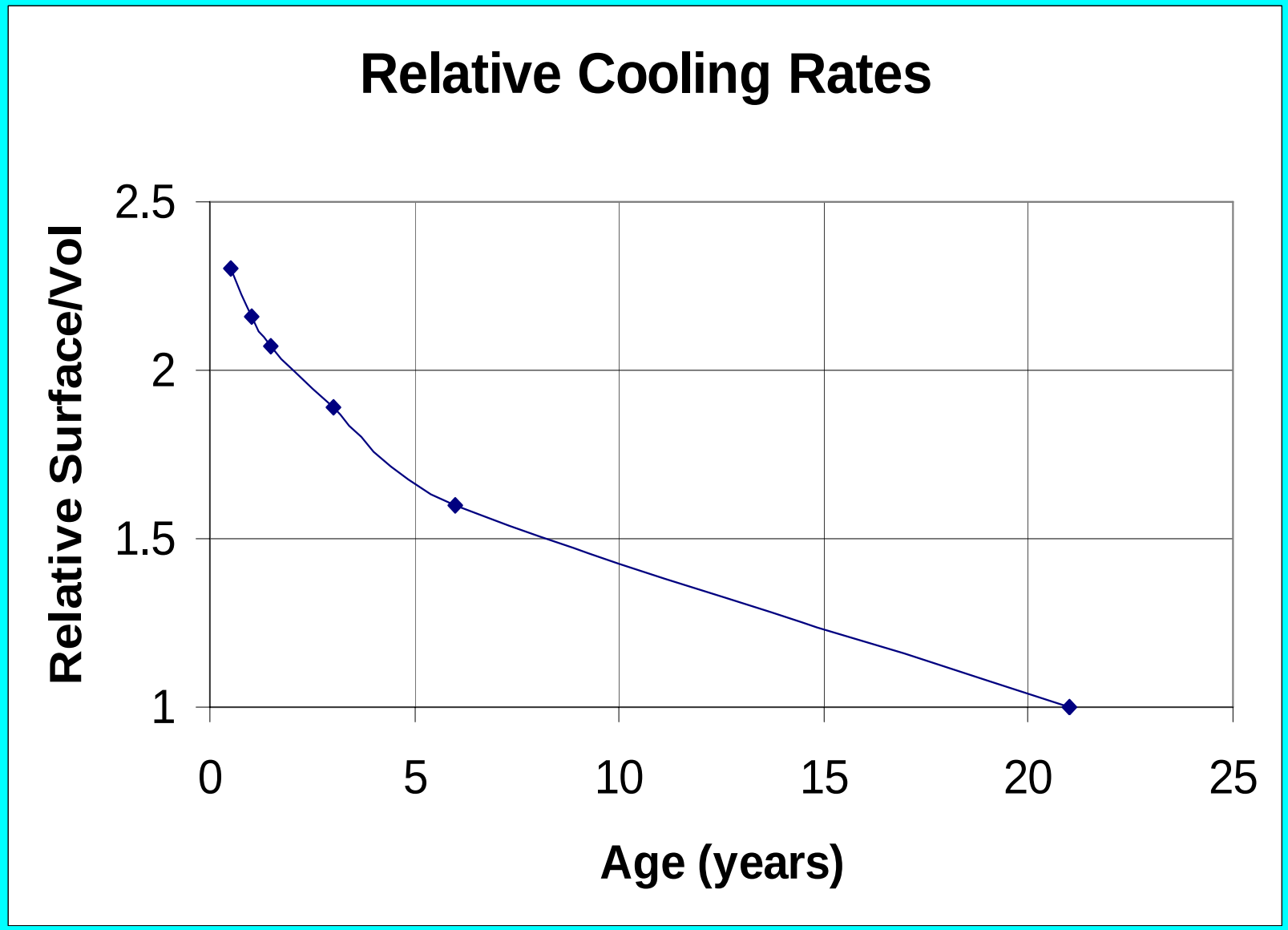
Case study 1

- Man falls asleep while tending 11-month boy
- Awakens to “thump, thump … thud” and finds infant on back at bottom of stairs with obvious head injury.
- Estimates a few minutes until calls 911 at 3:05 PM
- Paramedics arrive quickly, apply CPR and transport infant to hospital
- Child’s temperature is 93.8°F at 3:55 PM
- Low temperature leads prosecutor to speculate that man actually murdered the infant much earlier.

Surface to Volume Ratios

- Cooling rate should depend on S/V ratio.
- Body dimensions (torso) available from crash test dummy specifications.





www.ftss.com for biofidelic crash test dummy dimensions

Scaling to Infants

- Expect a one-year old to cool 2.2 times faster than a typical adult.
- Adult's 1.5 F°/h → 3.3 F°/h for infant.
- This still requires too much time.

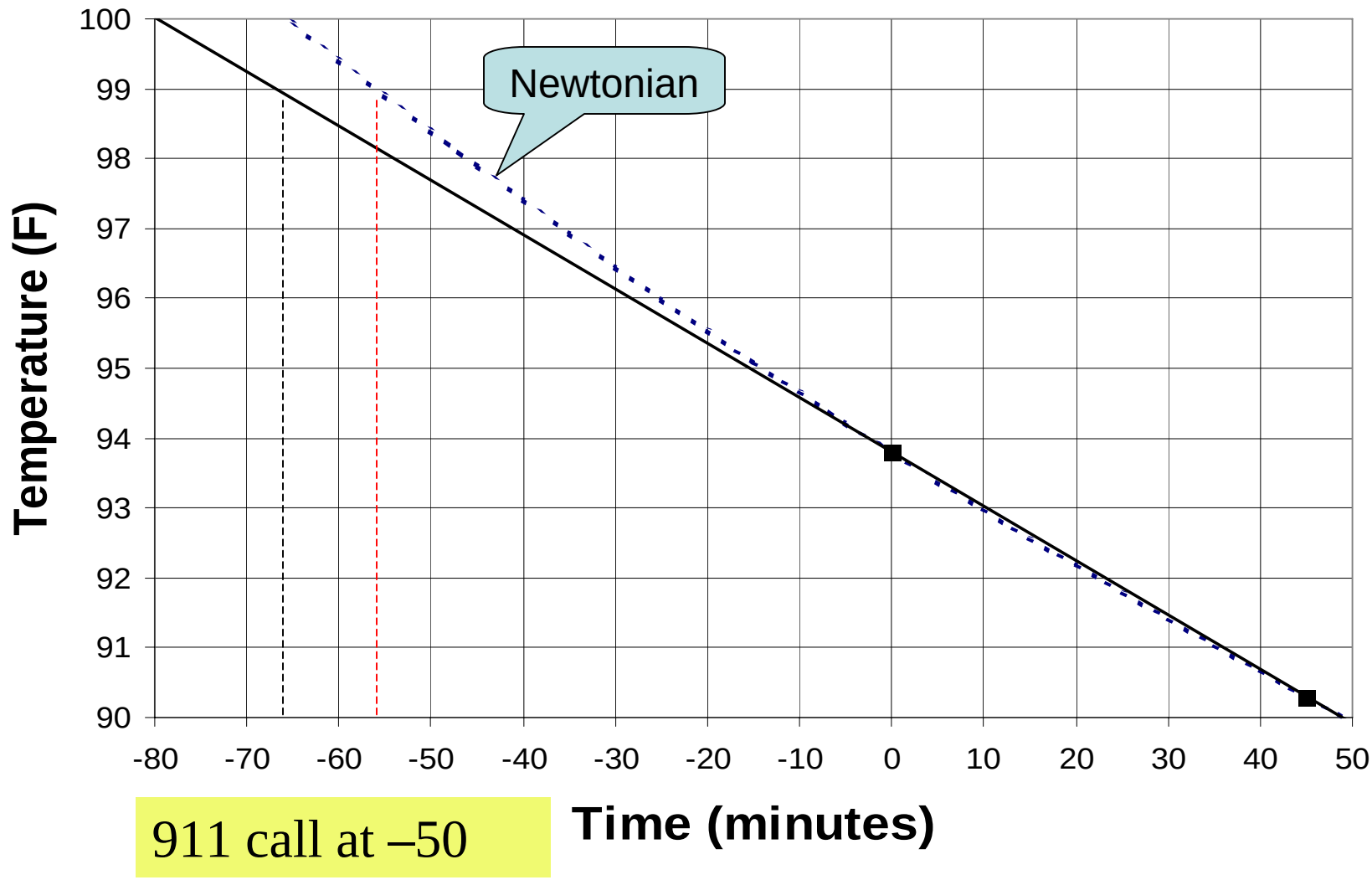
2nd Data Point

- 4:40 pm 90.3°F (45 minutes after 1st)
- Linear extrapolation
- Newton's exponential extrapolation

$$dT/dt = -A(T-70\ F)$$

- → $T = (To-70°F)\ \exp(-A\ t) + 70°F$

Cooling Extrapolation



911 call at –50

Basal Cooling Realizations

- Deep shock may turn off metabolic activity.
- Thermal equilibrium requires heat loss = basal metabolism.
- CPR with bag valve → same cooling rate.
- Entire cardiovascular surface area involved

Basal Metabolism Calculator

- www.room42.com

- 20 lb, 28 in tall, 0.94 y-old male
  → 627 kcal/day = 30.3 W

Accelerated Cooling Rates

Human body average specific heat c = 0.83 →

3470 J/(kg-C°)

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30.3 W = dQ/dt = mc dT/dt, where m = 9.07 kg
Theory → Initial dT/dt = -3.47 C°/h = - 6.24 F°/h

Experimental curve extrapolated to 99°F at
–55 minutes → Initial dT/dt = - 6.14 F°/h

Case 1 conclusions

- Experimental and theoretical results for initial cooling rate agree within 2%.
- There is NO apparent discrepancy with the defendant's account.
- This should be presented to the jury. T or F

PROSECUTOR: "Again, Your Honor, I don't think this witness has any experience in the medical area to be able to relate Newton's law of cooling to a human body. They're apples and oranges, totally different things that wouldn't even apply in this case. My understanding of Newton's law of cooling has to do with metals and steel and other areas that I don't think that has relevance to this case." Trial transcript p. 1835.

DEFENSE objects …

THE COURT: “Sorry. This is beyond his area of expertise. We’re not talking about some inanimate object. There’s too many factors involved that we don’t know or he doesn’t know that he would be able to express that opinion.”

Trial transcript p. 1838.

Ultimate Outcome

Man is convicted and sentenced to life in prison without parole.

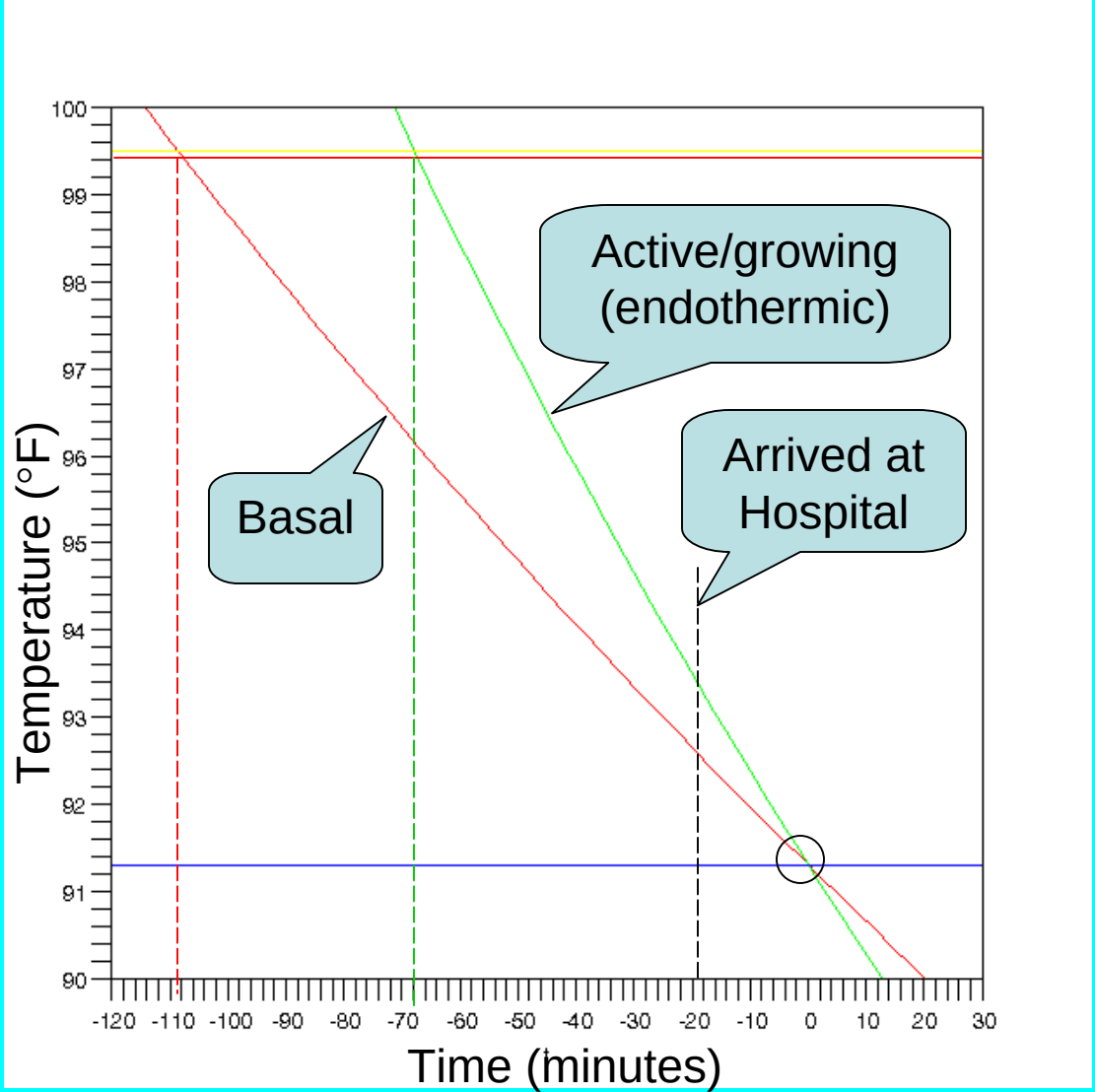
Case Study 2

- Man reports that 3-month boy slips from his grasp after bath and falls to floor
- Man realizes severe head injury because of lump and gets baby to hospital roughly 15 minutes later.
- Admitting nurse notes baby is cold upon arrival
- 20 minutes later temperature is 91.3°F

Suspicious evidence

- 2 separate skull fractures
- 2 broken ribs (CPR?)
- Soaking wet stockings on baby (not urine)
- Man’s shirt was wet
- Cold ice pack on bathroom counter at home
- One Sony Playstation controller missing (murder weapon?)
- Marijuana in home

Cooling of 3-month boy, 13.6 lb, 24”



Mother home until
-115 minutes

VERDICT: First-degree murder

- Detective aware of temperature analysis
- Reimann **NOT** called to testify
- Might vigorous CPR be a redeeming quality?
- Could “It’s all my fault!” be a cover-up?

My next step?

A. Let sleeping dogs lie.

B. Insist defense attorney examine these possibilities.

C. Try to visit the defendant.

D. Try to publish these results.

E. None of these

What about you?

I am willing to help with this research.

T or F

Thank you for your attention.

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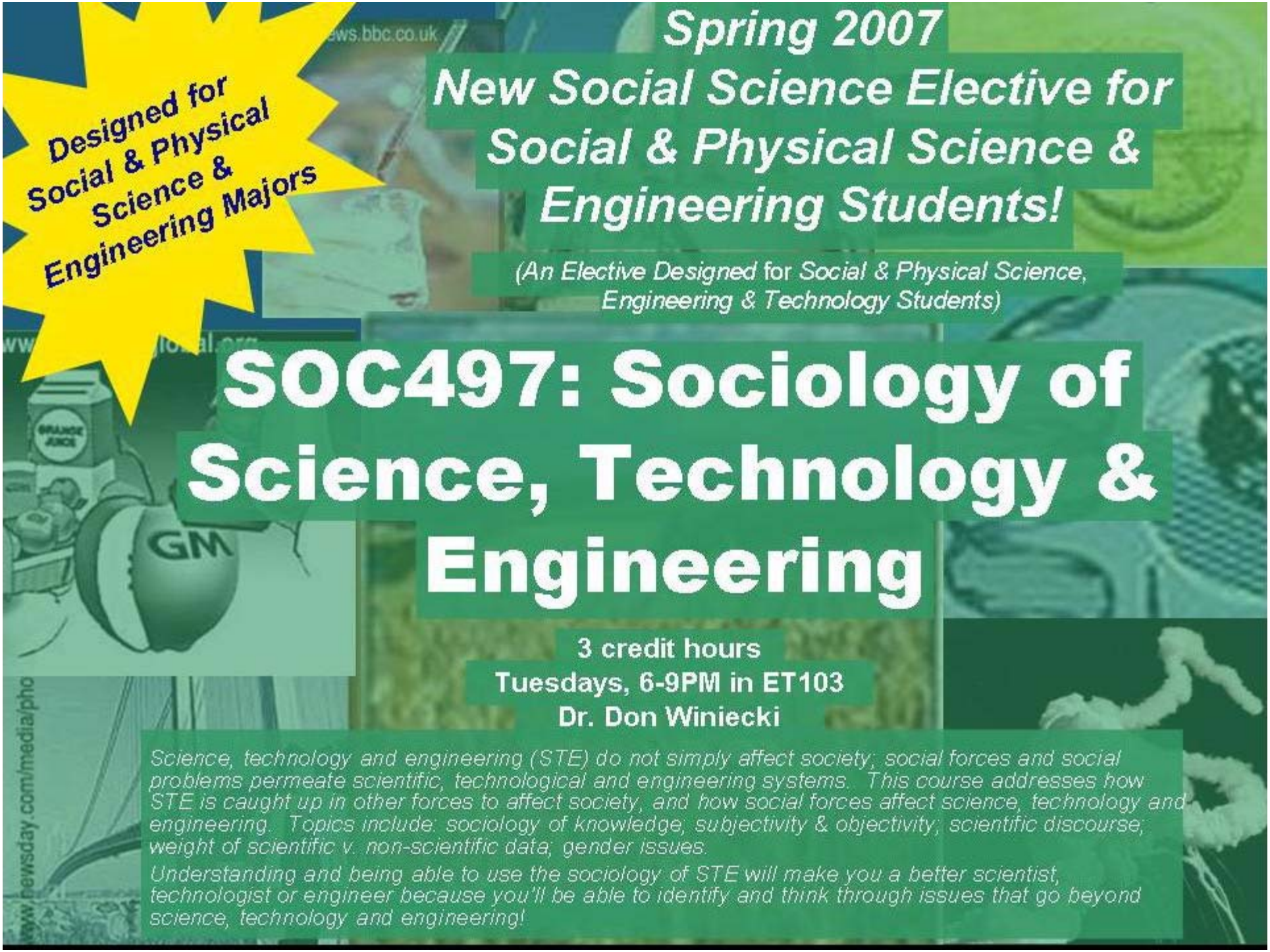
Any questions?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