STEM Society Meeting, March 14, 2017

James Emery

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1 About the STEM Society and the STEM Society Website

STEM is an abbreviation for Science, Technology, Engineering and Mathematics. The acronym STEM is commonly associated with K-12 education, but our use of the term is only slightly bound to this meaning. There are over one hundred people on the mailing list, although a much smaller group attends any one meeting. We meet on the second Tuesday of each month at the Trailside Center at 99th and Holmes in Kansas City, Missouri. The meetings are open to all. The start time is 6PM. We make presentations, have discussions, and have demonstration experiments. These relate to Science, the History of Science, Mathematics, Engineering, Philosophy and Technology at all levels. The topics have ranged from a technical discussion of the Mathematics of General Relativity to scientific experiments for young students.

These meeting notes contain links to many other documents, which may be viewed or downloaded by clicking the link. A partial list of documents can be reached by clicking the heading **Documents**. The meeting notes may also be viewed in an archive file (archive.pdf), which is in the list of documents. Many of the documents are PDF files. They may be viewed or downloaded to the computer by clicking, provided Adobe Reader, or another program capable of reading PDF files, is present. There are many more documents available at the site than are listed under **Documents** because the documents.htm file is not at all up to date. The last time I checked, about March 2014, there were about 350 document files on the site. We are in the process of creating better techniques for finding documents and authors. The first meeting of the STEM Society was in November of 2006. For several years we used the content management program called Joomla. It had a fancy looking interface, but was hard to use. It overran the space somehow at our internet provider Bluehost. So we now have a very simple HTML site. It is not so slick looking as Joomla, but is very easy to maintain and modify.

The web site is:

`http://www.stem2.org/`

Direct to the documents list:

`http://www.stem2.org/je/documents.htm`

Direct to the archive file:

`http://www.stem2.org/je/archive.pdf`

2 The March 14, 2017 Meeting Announcement

The March meeting of the STEM Society will take place on the second Tuesday of the month, March 14, 2017, at the Trailside Center at 99th and Holmes in Kansas City, Missouri. The starting time is 6PM. Also look at our website for past meeting notes:
The web site is:

`http://www.stem2.org/`

Possible Topics and Discussions:

(a) Jim Emery will present a couple of book reviews:

Oliver Sacks, **Uncle Tungsten: Memories of a Chemical Boyhood**, Vintage, 2001.

And

Gordon Richard, **The Alarming History of Medicine**, St Martin's Griffin, 1993.

(b) I will bring a recently printed copy of my book "Computational Mathematics," which I forgot to bring last meeting.

(c) Relativity without equations. Actually, I have a bit of a problem seeing how ignoring equations makes something easier to understand; I think ignoring equations makes it nearly impossible to understand, although I guess relativity in English might be easier for me to understand, than relativity in Chinese, and for some I suppose equations are Chinese.

That reminds me of an old Woody Allen joke delivered when Woody did stand up: "I just took an Evelyn Wood speed reading class, and it works. I just read War and Peace in an hour ... It's about Russia!

So anyway, I might find some relatively (no pun intended) simple problems to work through.

(d) Rich Kaufman: "I am reading a very interesting book on the subject of preparing vaccines for viral diseases like polio and shingles. The history is fascinating to me as it involves some really innovative thinking plus some really difficult obstacles from cultural issues and legal stuff."

(e) Tom Grant: I would like to discuss the following problem at the meeting:
Which takes less energy, to ride a bike up a hill or to push the bike up the hill?

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Possible answers:
A. Ride the Bike
B. Push the Bike
C. Can't tell from the information given
D. Depends on the hill
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(f) We should get some walk-in contributions from others. Perhaps you had a really exciting scientific summer vacation or winter vacation on the beach dreaming of figures, or perhaps of melting icebergs.

3 Tom Grant: Riding or Pushing, Did Sisyphus Need a Bicycle?

Comments on the New Scientist Magazine Issue of November 20, 2013 on a writing competition for 100 pounds, on the topic of the energy used by a person riding or pushing a bicycle up a hill. Tom Grant entered this competition. He was told by New Scientist that he would probably win the competition if he were subscribed to the magazine. Tom declined to subscribe. Later it turned out that they decided to not award the prize to anyone.

We had a fairly long discussion about this competition. Tom presented much convincing research on the subject, showing several graphs. There was a fair amount of arguing, much of it as usual, probably caused by a failure to understand one another. This problem illustrates well **The First Law of**

Thermodynamics, and the process of human metabolism.

Tom: "Just to restate my position:

(1.) The bike on flat ground is several times more efficient than walking.

Here are some links:

Bicycling the most efficient means of transport

https://www.exploratorium.edu/cycling/humanpower1.html
https://en.wikipedia.org/wiki/Bicycle_performance
http://www.bikeboom.info/efficiency/

(2.) Speed (or high heart rate) works against efficiency but both walker and biker can go at whatever speed (or cadence for the biker) is the most efficient for them:
There is a most efficient speed for both running and bicycling:

http://www.exrx.net/Aerobic/WalkCalExp.html
http://www.sportsci.org/jour/9804/dps.html

(3.) Scientists measure the metabolic efficiency in the laboratory by measuring oxygen uptake and CO_2 exhale. This covers all aspects of the bike rider except wind resistance which if you look at the curves it is low at the speeds we are talking about. This includes your griping the handlebars issue you brought up (although bikers balance themselves against the handlebars not actually grip them unless they need to stand for power).

http://jbpierce.org/metabolic-fitness-testing-laboratory/

(4.) As the hill gets steeper or rougher the bike rider starts to loose advantage because he cannot go at the most efficient cadence, but starting out so much more efficient the bike rider will be still more efficient except for very steep (maybe grade greater than 25 percent) or very rough rocks. Exact crossover point is subject to experiment.

(5.) This conundrum is debated in a surprising number of forums and you can find all sorts of opinions on the internet including some very unscientific.

https://www.reddit.com/r/askscience/comments/23plne/does_biking_uphill_require_more_energy_than/

Hope this helps.

4 Panofsky, His Book, and a Brief History of Accelerators

Wolfgang Kurt Hermann "Pief" Panofsky (April 24, 1919 September 24, 2007), was a German-American physicist who won many awards including the National Medal of Science. He was head of the Stanford Linear Accelerator Center in Palo Alto for many years.

Panofsky was born the son of renowned art historian Erwin Panofsky in Berlin, Germany. He received his bachelor's degree from Princeton University in 1938 and earned his Ph.D. in physics from the California Institute of Technology in 1942. In April 1942 he was naturalized as a U.S. citizen.

From 1945 to 1951, Panofsky held an assistant and then associate professorship at the University of California, Berkeley, before permanently establishing himself as Professor of Physics at Stanford University. Between 1961 and 1984, he was the director of the Stanford Linear Accelerator Center and continued to serve as director emeritus.

Panofsky died at the age of 88 on September 24, 2007 in Los Altos, California, from a heart attack. Panofsky stayed active at SLAC until his last day of life

Panofsky's Book Classical Electricity and Magnetism by Wolfgang Panofsky and Melba Phillips (1955, 1962, 1983, 1990): This book gives an accurate treatment of electricity and magnetism in its classical form and explains in detail the transition to its relativistic formulation. The original ideas are explained in great detail and thus make the book extraordinarily understandable, whereas modern books many times fall short in such explanations. I own the first edition, which I must have obtained from a used book store some time ago.

Chapters 14 through 24 contain a relativistic treatment of electromagnetism and some application to accelerator physics.

Linda Hall Library 2nd edition 1962:

Classical Electricity and Magnetism, by Wolfgang K.H. Panofsky and Melba Phillips. Panofsky, Wolfgang K. H. (Wolfgang Kurt Hermann), 1919-2007. Phillips, Melba, 1907-2004 1962 Available at LHL Books - Closed

Stacks (QC518 .P35 1962)

The reprint of this edition by Dover is still in print.

Wofgang Panofsky was the son of **Erwin Panofsky,** who was Born March 30, 1892 in Hannover Germany, and died March 14, 1968 in Princeton, New Jersey. Erwin Panofsky was a world famous art critic, who fled Nazi Germany for America in the early thirties. Panofsky was known to be friends with physicists Wolfgang Pauli and Albert Einstein. He was at the **Institute for Advanced Study** in Princeton from 1935 until his death.

Edwin Panofsky wrote the book **The Life and Art of Albrecht Dürer** (1943). One can find an article titled **Dürer as mathematician** by Erwin Panofsky, which I think is extracted from his book, and appears in one of the four volumes of **The World of Mathematics**, edited by James Newman, and which was given to me as a Christmas present by my Grandmother when I was a teenager, and which I still have.

4.1 Panofsky's Short History of Accelerators

Wolfgang K. H. Panofsky, **The Evolution of Particle Accelerators & Colliders**,
www.slac.stanford.edu/pubs/beamline/27/1/27-1-panofsky.pdf

5 Book Reviews

Uncle Tungsten, by Oliver Sacks, is available at Johnson County Library.

The Alarming History of Medicine, By Richard Gordon, is available at the Antioch branch of the Johnson County Library.

5.1 Uncle Tungsten

Johnson County Library description: *From his earliest days, Oliver Sacks, the distinguished neurologist who is also one of the most remarkable*

storytellers of our time, was irresistibly drawn to understanding the natural world. Born into a large family of doctors, metallurgists, chemists, physicists, and teachers, his curiosity was encouraged and abetted by aunts, uncles, parents, and older brothers. But soon after his sixth birthday, the Second World War broke out and he was evacuated from London, as were hundreds of thousands of children, to escape the bombing. Exiled to a school that rivaled Dickens's grimmest, fed on a steady diet of turnips and beetroots, tormented by a sadistic headmaster, and allowed home only once in four years, he felt desolate and abandoned. When he returned to London in 1943 at the age of ten, he was a changed, withdrawn boy, one who desperately needed order to make sense of his life. He was sustained by his secret passions: for numbers, for metals, and for finding patterns in the world around him. Under the tutelage of his "chemical" uncle, Uncle Tungsten, Sacks began to experiment with "the stinks and bangs" that almost define a first entry into chemistry: tossing sodium off a bridge to see it take fire in the water below; producing billowing clouds of noxious-smelling chemicals in his home lab. As his interests spread to investigations of batteries and bulbs, vacuum tubes and photography, he discovered his first great scientific heroes, men and women whose genius lay in understanding the hidden order of things and disclosing the forces that sustain and support the tangible world. There was Humphry Davy, the boyish chemist who delighted in sending flaming globules of metal shooting across his lab; Marie Curie, whose heroic efforts in isolating radium would ultimately lead to the unlocking of the secrets of the atom; and Dmitri Mendeleev, inventor of the periodic table, whose pursuit of the classification of elements unfolds like a detective story. Uncle Tungsten vividly evokes a time when virtual reality had not yet displaced a hands-on knowledge of the world. It draws us into a journey of discovery that reveals, through the enchantment and wonder of a childhood passion, the birth of an extraordinary and original mind.

Jim Emery Review of Uncle Tungsten

Oliver Sacks was a neurologist and a prolific writer. He was born in 1933 in London. He received an MD degree from Queens College London in 1960 and also pursued further education at UCLA. Oliver was the youngest of four children. His mother was the first female surgeon in London; his maternal grandfather Mordechai Fredkin was born in a small Russian village in 1837 and avoided impression into the Russian Cossack army by fleeing Russia using the passport of a dead man named Landau, when he was sixteen.

The grandfather took the name Marcus Landau, he married very young and had 18 children, and he was a polymath and an autodidact and encouraged his family to obtain education. Oliver's mother (née Landau) was the 16th child, she studied chemistry and became a physician and surgeon, the Landau family was huge, many were scientists, doctors and mathematicians. Oliver Sacks had about 100 cousins, living all over the world, several engaged in mining in South Africa. The huge family was close and had frequent family reunions and visits. Oliver's education was aided by his mother who taught him chemistry, and had him dissect a corpse at her hospital at a young age. His two older brothers Marcus and David, who were nine and ten years older than he was demonstrated magnets, electricity, and a brother Michael gave him a crystal set and so on. Marcus and David became physicians. His uncle Tungsten as he was known, was Dave Landau, who operated a large electric light bulb factory in London and experimented with metals and chemicals. His uncle Abe Landau had a business dealing with radioactive materials and inventions, such as an accurate clock that ran for years using a radioactive source. Abe had sores on his hands from working with radium. Oliver's father was a physicians; the family home was very large, and the family upper middle class. During the second world war Oliver was exported for safety from the London bombing, to an austere rural school, where he had a rather Dickensonian existence throughout the war. When he returned home after the war ended at age ten, he started experimenting seriously with chemistry in his home laboratory, aided by his parents and the two uncles who's factories he visited often. Oliver hung out at South Kensington Libraries and Museums. He had access to chemicals, many dangerous from suppliers in London who in those days would sell to anyone including young boys. For example Oliver would reduce ores to the pure metals. His Uncle Tungsten had large collections of exotic metals which he experimented with using them as filaments. One of the museums he visited, the geological museum, had a display of the periodic table consisting of cubby holes containing actual samples of the elements. Oliver loved to play with uncle Abe's's spinthariscope, having a fluorescent screen and an eyepiece through which one could observe radiation from a small sample of radium.

This little book contains also an outline of the history of chemistry with little biographes and so on. Oliver was an autodidact as every one should try to be, and this should be encouraged by teachers. Unfortunately teachers sometimes act as though knowledge must come from them.

Oliver was also a childhood friend of Johnathon Miller, who is a physician

and a member of the famous comedy group called "Beyond the Fringe," who wrote the book "The Body in Question," and a series of TV shows on Atheism, and a well known producer of operas and plays in England.

Oliver made a friend later in life (the Nobel Prize winning chemist Roald Hoffman), who encouraged him to write the book "Uncle Tungsten," about his chemical boyhood. Roald Hoffman is also responsible for the set of videos called "The World of Chemistry."

This is an extremely interesting book and very well written, so that I may well read it over and over.

5.2 The Alarming History of Medicine

From Publishers Weekly *Best known for his novels, particularly Doctor in the House, Gordon here presents unusual insights into medical advances. Although noting that, "Religion is of course a Good Thing, offering the valuable incidentals of saddling assertive man with someone more important than himself, it scuppered healing for fifteen centuries." That being the case, Gordon's irreverent, witty and rich florilegium of medical milestones is largely confined to the last couple of centuries. He demonstrates that many medical milestones resulted from fallacies, luck or serendipity–citing the role of barbers and warfare in promoting surgery–and that forgotten laboratory bacterial specimens led to a cholera vaccine and the discovery of penicillin. According to Gordon, Darwin, a non-doctor, "founded genetics knowing nothing about DNA," and industrial chemist Pasteur stumbled on the microbes leading to pasteurization and vaccination while investigating adulterated wine and beer. The instructive, entertaining lode of superstitions and facts inludes hilarious suggested origins for the word condom and an apt takeoff on Freud treating a patient.*

6 The π Meson (pion)

A π meson, (a hadron) consists of two quarks an up quark and a down antiquark. It has a decay time of 2.6×10^{-8} seconds in a rest frame, which is 26 nanoseconds. They can be produced by bombarding a target in an accelerator with high energy protons. The mesons move out of the target at speed $.99c$, where c is the velocity of light, so that the decay time in the laboratory frame is $t = \gamma 2.6 \times 10^{-8}$, so that they move a distance about tc. This is called time

dilation. A python program given below called timedilation.py does this calculation and agrees with a measured distance value. This demonstrates the validity of the Lorentz transformation and time dilation. see Katz p33.

7 Relativity

Calculations involving the Lorentz transform are simple, but tedious, so I decided to write some little programs in Python to reduce the calculation time. These programs run on the command line, as all programs should, unless special graphical visualization and creation is required.

7.1 The Lorentz Transformation Program

The Lorentz Transformation relating the two coordinate systems is

$$x' = \gamma(x - vt)$$

$$y' = y$$

$$z' = z$$

$$t' = \gamma(t - \frac{xv}{c^2}),$$

where v is the velocity of the primed system with respect to the unprimed system, c is the velocity of light, and

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}}.$$

The inverse Lorentz transformation is

$$x = \gamma(x' + vt')$$

$$y = y'$$

$$z = z'$$

$$t = \gamma(t' + \frac{x'v}{c^2}),$$

where we reverse the sign of v.

lorentz.py Python program to compute the Lorentz transformation.

```
# lorentz.py, the Lorentz Transformation 3/13/17
# r=ratio of the velocity of the primed coordinate system,
# (0 <= |r| < 1), with respect to the speed of light c.
# x is the space coordinate in the unprimed system.
# t is the time coordinate in the unprimed system.
# xp is the computed space coordinate in the primed system
# tp is the computed time coordinate in the primed cordinate system
import sys
#print sys.argv
#print sys.argv[0]
na=len(sys.argv)
#print "number of arguments",na
if( na < 4):
 print "lorentz.py, with parameters r,x,t, where"
 print " where r is the ratio of the velocity of the primed coordinate system "
 print " (0 <= |r| < 1) with respect to the speed of light c,"
 print " x is the unprimed space coordinate,"
 print " t is the unprimed time  coordinate."
 print " xp and tp are the corresponding computed values in the primed system."
 print " Example values r=.9, x=1., t=1.e-8"
 print " Usage: python lorentz.py r x t"
 sys.exit(0)
import math
c=3.e8
r=float(sys.argv[1])
x=float(sys.argv[2])
t=float(sys.argv[3])
#r=.1
v=r*c
print " r=",r
print " x=",x
print " t=",t
gamma=1./(math.sqrt(1.-v*v/(c*c)))
print " gamma=", gamma
print " v*t=",v*t
xp=gamma*(x-v*t)
tp=gamma*(t - (v*x)/(c*c))
print " xp= ",xp
```

```
print " tp= ",tp
```

Running the Program without parameters for information:

```
c:\je\py\>python lorentz.py
 lorentz.py, with parameters r,x,t,
 where r is the ratio of the velocity of the primed coordinate system
 (0 <= |r| < 1) with respect to the speed of light c,
 x is the unprimed space coordinate,
 t is the unprimed time  coordinate.
 xp and tp are the corresponding computed values in the primed system.
 Example input values r=.9, x=1., t=1.e-8
 Usage: python lorentz.py r x t
```

Running the Program with parameters:

```
c:\je\py\>python lorentz.py .9 1.0 1.e-8
 r= 0.9
 x= 1.0
 t= 1e-08
 gamma= 2.29415733871
 v*t= 2.7
 xp=  -3.9000674758
 tp=  1.60591013709e-08
```

7.2 Time Dilation Program

```
# timedilation.py, time dilation  3/13/17
# r=ratio of the velocity of the primed coordinate system,
# (0 <= |r| < 1), with respect to the speed of light c.
# dt' is the time interval in the primed system.
# dt is the computed time interval in the laboratory coordinate system
import sys
#print sys.argv
#print sys.argv[0]
na=len(sys.argv)
#print "number of arguments",na
```

```
if( na < 3):
 print "timedilation.py, with parameters r, dt', where"
 print " where r is the ratio of the velocity of the primed coordinate system "
 print " with respect to the speed of light c (0 <= |r| < 1)."
 print " dt' is the primed time interval,"
 print " dt is the dilated computed value in the unprimed laboratory system."
 print " Example values r=.99, dt'=2.6e-8 (the decay rate of pi muons)"
 print " Usage: python timedilation.py r dt'"
 sys.exit(0)
import math
c=3.e8
r=float(sys.argv[1])
dtp=float(sys.argv[2])
#r=.1
v=r*c
print " r=",r
print " dt'=",dtp
gamma=1./(math.sqrt(1.-v*v/(c*c)))
print " gamma=", gamma
dt=gamma*dtp
print " dt= ",dt
print " dt*c=", dt*c, "meters"
```

Running the Program

```
c:\je\py\>python timedilation.py .99 2.6e-8
r= 0.99
 dt'= 2.8e-08
 gamma= 7.08881205008
 dt=  1.98486737402e-07
 dt*c= 59.5460212207 meters
```

Because the pion reflection travels near the speed of light, in the laboratory frame the length of the path is about $cdt = 59$ meters on average.

7.3 Lorentz Contraction Program

We also have a Length contraction program

```
# lengthcontraction.py, time dilation  3/13/17
# r=ratio of the velocity of the primed coordinate system,
# (0 <= |r| < 1), with respect to the speed of light c.
# dx is the length in the the laboratory coordinate system.
# dx' is the computed contracted length in the laboratory coordinate system
import sys
#print sys.argv
#print sys.argv[0]
na=len(sys.argv)
#print "number of arguments",na
if( na < 3):
 print "lengthcontraction.py, with parameters r, dt',"
 print " where r is the ratio of the velocity of the primed coordinate system, "
 print " with respect to the speed of light c (0 <= |r| < 1)."
 print " dx' is the interval length in the primed system,"
 print " dx is the computed contracted value in the laboratory system,"
 print " We have dx=dx'/gamma, where gamma > 1."
 print " Example of input values r=.99, dx=1"
 print " Usage: python timedilation.py r dx"
 sys.exit(0)
import math
c=3.e8
r=float(sys.argv[1])
dxp=float(sys.argv[2])
#r=.1
v=r*c
print " r=",r
print " dxp=",dxp
gamma=1./(math.sqrt(1.-v*v/(c*c)))
print " gamma=", gamma
dx=dxp/gamma
print " dx= ",dx
```

7.4 Jim Emery's Document on Relativity

Emery James, **Relativity**, /stem2.org/je/relativ.pdf

8 Rich Kaufman Book Discussion "The Vaccine Race"

Rich discussed the book:

[1] Wadman Meredith, **The Vaccine Race: Science, Politics, and the Human Costs of Defeating Disease**, 2017, Viking. ISBN-13: 9780525427537 0525427538.

"The epic and controversial story of a major breakthrough in cell biology that led to the creation of some of the world's most important vaccines. Until the late 1960s, tens of thousands of American children suffered crippling birth defects if their mothers had been exposed to rubella, popularly known as German measles, while pregnant; there was no vaccine and little understanding of how the disease devastated fetuses. In June 1962, a young biologist in Philadelphia, using tissue extracted from an aborted fetus from Sweden, produced safe, clean cells that allowed the creation of vaccines against rubella and other common childhood diseases. Two years later, in the midst of a devastating German measles epidemic, his colleague developed the vaccine that would one day wipe out homegrown rubella. The rubella vaccine and others made with those fetal cells have protected more than 150 million people in the United States, the vast majority of them preschoolers. The new cells and the method of making them also led to vaccines that have protected billions of people around the world from polio, rabies, chicken pox, measles, hepatitis A, shingles and adenovirus. Meredith Wadman's masterful account recovers not only the science of this urgent race, but also the political roadblocks that nearly stopped the scientists. She describes the terrible dilemmas of pregnant women exposed to German measles and recounts testing on infants, prisoners, orphans, and the intellectually disabled, which was common in the era. These events take place at the dawn of the battle over using human fetal tissue in research, during the arrival of big commerce in campus labs, and as huge changes take place in the laws and practices governing who "owns" research cells and the profits made from biological inventions. It is also the story of yet one more unrecognized woman whose cells have been used to save countless lives. With another frightening virus imperiling pregnant women on the rise today, no medical story could have more human drama, impact, or urgency today than The Vaccine Race" – Provided by publisher.

8.1 The Hayflick Limit

The Hayflick limit or Hayflick phenomenon is the number of times a normal human cell population will divide until cell division stops. Empirical evidence shows that the telomeres associated with each cell's DNA will get slightly shorter with each new cell division until they shorten to a critical length.

9 References

[1] Panofsky Wolfgang K. H., Phillips Melba, **Classical Electricity and Magnetism**, 2nd Edition, 1962, LHL QC518 .P35, Addison-Wesley.

[1] Panofsky Erwin, **The Life and Art of Albrecht Dürer**, 1943.