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We began our discussion Monday with Galileo. Something I wondered right off the bat about him was why he is referred to by his first name while most of the other people we've learned about are known by their last name. Even a non-science person such as myself recognizes the name Galileo, but would have no idea who "Galilei" was. And I can't help but wonder—what were his parents thinking giving him a name like Galileo Galilei anyway?

We talked about how the prevailing wisdom of the time was still Aristotelian. The Categories of Aristotle included quantity, but most didn't think that a quantitative description of motion was interesting or important; except for Galileo who favored connections between natural phenomena and the world. In his large book, he named five important notions important to considering motion: free fall, the pendulum, constant accelerated motion, projectile motion, and a disagreement with Aristotle about the dynamics of free fall. What amazes and puzzles me about Galileo is that he studied and discovered so many amazing things but didn't have a system he followed—Professor Brock said that his work is largely a collection of items each standing alone as significant.

Galileo set out to explore accelerated motion and wanted to do so by measuring falling objects, but lacked both clocks and the means of measuring short intervals of time. He reasoned he could measure time based on the motion of a pendulum. Such motion, he argued, implied that the speeds at the bottom of the swing of the pendulum were the same regardless of where the pendulum started. Galileo hypothesized that he could measure motion using inclined planes with the same reasoning, and using his pulse, a water-drip clock he invented, a pendulum, and music, he extrapolated new information about motion: the period of the pendulum depended on the length of the cord and was governed by the same influence as free fall. He concluded that freely falling motion is accelerated motion and is uniformly accelerated.

Additionally, Galileo conceived projectile motion as two different motions: as both horizontal and vertical. Galileo used time as the parameter to connect these two motions, and Professor Brock argued that our modern notion of vectors is connected to this. Galileo's genius, Professor Brock claimed, was the realization that horizontal motion is constant, vertical motion is decelerated, and that the resulting motion is a parabolic path.

What I find amazing about Galileo's research is that he never saw a pendulum or parabolic path in the ways he wrote about—he merely represented the phenomena using perceived behavior hiding in fundamental physics. He was the first to explore such ideas of motion and observe more than what he saw. While some people wonder if he ever actually performed any experiments, I have to believe that he did; how else could he have made such accurate predictions about motion?

However, Professor Brock did tell us that the whole “Leaning Tower” experiment of Galileo’s was a hoax. Some believe that Galileo claimed he could drop two bowling balls of different weights from the top of the Leaning Tower of Pisa and that they would land at the same time. This claim is now believed to be erroneous because if Galileo had performed such an experiment, he would find that the bowling balls would land more than a meter apart because of air resistance. This argument has been deemed more experimental than logical.

We talked a bit about relativity too; specifically the “ball-off-the cliff” scenario where a ball falls from a ship mast and the perspectives of what it looks like are different on land than on the deck of the ship. This observation helped Galileo realize that the ball favored the horizontal motion of the ship. It also led to the conclusion in his principal of relativity which claims that one cannot perform an experiment to determine whether one is in a state of uniform motion or one of rest because the frame of reference prevents one from making an observation that is both accurate and constant. This notion reminds me of earlier discussions about art where we claimed that no artist’s work could be deemed purely realistic or true because of the subjectivity involved in viewing and observing something.

We wrapped up Galileo with a look at all he has contributed to science. To begin, he warned us to be careful of what we say and how we say it, and that there is a proper attitude required to do science. He taught us that objects falling in gravity undergo constant accelerated motion near the earth, that the distance traveled by such objects is proportional to the square of the time elapsed and that violent motions are the same as natural motions and are separate motions which are coupled together. He hypothesized that objects at constant speed will stay constant forever (thus the Aristotelian “push” isn’t necessary), and that the rules of the pendulum are similarly affected by gravity and free-fall. Finally, Galileo showed us how to abstract a complicated problem into pieces which can be embraced by simple, uniform explanations which suggest physical regularities (laws).

For the last part of Monday and the rest of Wednesday’s lecture we moved into the late Renaissance era. Professor Brock said a few last words about Descartes, specifically mentioning that Descartes was able to separate the realm of thinking (the mind) from that of matter (the body). For Descartes, nature as an inanimate matter was knowledgeable and mechanical. Matter, he argued, had two properties: spatial extension (length, depth, and height) and motion. Near the end of his life he wrote the influential *Principles of Philosophy,* catching the attention of Newton by laying out his physics, the first concept of inertia, and writing about what causes objects to stop. Additionally, Descartes believed that the earth was full and infinitely divisible. The universe, he claimed, was a “plenum” with three characteristics: small spheres which cause motion of vortices, planets swept by the vortices into orbits and kept in place by the spheres, and aether—smaller spheres filling space. Descartes believed that God started all motion and it was propagated through plenum to objects. Collision, then, was the mechanism by which things moved and was a direct contact of plenum bodies. The total quantity of motion in the universe was believed to be constant, and thus was the original “push” that started all motion. This discussion was a bit complex for me, but probably because I don't think I fully understand terms like "aether" and "plenum."

Descartes' findings were complex and intricate but contained traces of modern ideas. Locality is an important concept in modern theories, especially regarding the attraction between opposite electrical charges. Calculus is a way of dealing with small, local changes in space and time. In fact, continuous differentiability is a requirement for a meaningful model. We now have understandable explanations for notions of mechanism and the knowledge that at their bases they are chemical and physical. Descartes also managed to banish Aristotelian forms and categories and believed that if something was clear and distinct, it was real. He also linked algebra and geometry, something that caught on quickly in the field of mathematics. He invented the axis and notion for powers as well. Cartesian reasoning had come to mean a "top-down" reasoning that was largely deductive.

On Wednesday we summarized the people who would change everything and basically give birth to physics. For Galileo, Aristotle's "local motion" was all of what motion is, and motion became independent of the object moving. By making motion mathematical and through the acceptance of constant and uniformly accelerated motion, metaphysics divorced from science. Kepler and Descartes ignored/didn't talk about metaphysics, but it wasn't until Galileo that it was separated from science altogether. My understanding of metaphysics is that it is the philosophy which examines the nature of reality, including the relationships between mind and matter, substance and characteristic, and fact and value. Based on what we've discussed in class so far, metaphysics calls into question the validity of scientific fact and observation and thus complicates the experimentation process. I understand that this could hinder scientific discovery, but isn't it important to call into question everything one observes and hypothesizes about? Isn't this how we confirm and attempt to establish fact? I might be way off here, but I guess I just wonder why Kepler, Descartes, and Galileo ignored and/or separated metaphysics from science.

Professor Brock explained to us what prompted him to connect art and physics to construct this course—he made the argument that both art and physics involve using vision when painting/experimenting to find out what's relevant, to eliminate what isn't, and to compare the remaining data to knowledge stored from experience. I understand his argument because in my writing course last year we spent a good deal of time examining the delicate relationship between an artist and his work. When looking at a piece of art or even photograph for that matter, it is important to note that its creator has made a conscious decision about what to include and omit. It had never occurred to me before this course that the same logic could be applied to scientific experimentation.

We looked extensively at four artists of the time period: Baroque, Bernini, Caravaggio, and Rembrant. Baroque pioneered the grotesque, absurd, and distorted style of painting called Mannerism or Realism. It was a deviation from classical style, shedding religiosity and authority to represent extreme motion, emotion, drama, and viewer involvement. Bernini brought this same concept to sculpture and was a true innovator of technique and intent, creating a sense of immediacy in the painting and charging the space between sculptor and viewer. Caravaggio was on a mission to discover truth, and he dismissed traditional techniques and painted from live models to engage the viewer with the painting. I was disturbed by his use of disembodied heads and a drowned prostituted to represent the Virgin Mary in one of his paintings, but I suppose that was his intent in painting them. Caravaggio in turn influenced Rembrant whose representations were calmer and almost photographic. He mastered the technique of representing facial expressions to transmit information. The Realism movement in art was incredible because of the artist's increasing ability to represent objects so accurately. I was amazed when Professor Brock showed us the close-up of bread in a painting which so closely resembled the texture of an actual piece of bread one might see on a table.

Next it was time to meet the scientists of the period and we started with Christian Huygens, an inventor of high respect who made improvements to lens-making and who, spurred by the astrological needs for accurate timekeeping, constructed the first clock. He was imaginative in mechanics, which was becoming a more quantitative field, and was able to find a geometrical way to understand collisions. We then turned to Robert Boyle, one of the first modern experimental physicists deemed the "Father of Chemistry." He was committed to public experimentation and discussion and created the first society in 1660 devoted to such principles. (He embo

dies one of the requirements of science we discussed on day one: that something has to be public to be science.) We talked about the intern he hired—Robert Hooke—who was inventive but not easy to get along with. Together, Boyle and Hooke designed and built a series of air pumps which proved to be a lot of work because they had to make the devices, fix, them, and upgrade them when necessary. With their pumps they studied the effects of vacuums on animals, flames, and sound. They measured the pressures and volumes of air at different temperatures and concluded that pressure and volume were directly proportional to temperature. They published all their findings and Professor Brock claimed that their experimentation was the first time anyone performed physics in its entirety.

Things were shaping up in science for something big. Mathematics was ready with the unification of algebra and geometry and physics was ready with Kepler, Galileo, and Descartes' findings. Three things were missing though: mass, action-reaction, and a guy like Newton to put it all together. (No pressure Newton…) We entered the Enlightment period or the "age of reason" where things were learned through observation, Democracy was in the air, commerce was bustling, and the public was reading and learning at a more rapid rate than before. Religion was losing its hold (probably partly as a result of the significant scientific discoveries being made) and it was believed that all that was knowable could be known. Finally, we took a peek at the man who made all this possible—Issac Newton. He was abandoned as a child, raised by his grandmother and worked for a time as a sizar—something that Professor Brock compared to a slave. When the plague broke out Cambridge was shut down, and it was during his "vacation" that Newton engaged in the self-study that led to the theory of colors/light and infinite series. (Much more than I've ever managed to accomplish during summer vacation!) He went on to become engrossed in mathematics and was appointed as the second Lucasian Chair. Unfortunately, bad encounters and collisions with Robert Hooke regarding his theories led him to completely withdrawal from public life later on in his career.