issues &events

Physicists in forensics

From faulty products to murder, physicists help figure out what really happened.

A young woman was found at the bottom of a cliff in Sydney, Australia, in June 1995. The site was a popular suicide spot, and the police assumed she had killed herself. But last November the woman's boyfriend was convicted of murder. "It took 10 years to figure out that the woman was thrown off the cliff; she did not jump," says Rod Cross, a physicist at the University of Sydney who served as a consultant for the case. It took that long, he adds, "mainly because the police did not understand that physics could help solve the problem."

Cross got into forensics by chance—he volunteered when the coroner called his department with a question. The same was true for Mark Semon of Bates College in Maine: As a new hire in that campus's physics department in the 1970s, he often answered the phone. "There were four of us in the department, and we had no secretary. All of us were on the same phone line—someone picked up and then buzzed whoever [the call] was for. One day it was a district attorney who asked if something [specific] could happen in an accident where the cars were traveling in adjoining lanes. I said, 'No, it violates conservation of momentum,' and she asked if I could come in to testify."

Easy physics, subtle applications

Since then, Semon has consulted on collision cases ranging from a car hitting a bull (claiming damages for his prize animal, the farmer sued and won) to a train plowing into a car (relatives of the car's driver sued the train company, claiming the train had been speeding; they won). "The main thing I've discovered," says Semon, "is that I can't use words like 'uncertainty' because the attorney on the other side says, 'Oh, you are uncertain.' So I settled on 'margin of error.' "

Consulting in forensics has enriched his teaching, Semon says. "I have found these cases to be great things to use in class. For example, it's fascinating to learn how a train brakes—each car brakes sequentially, it's a step function. I see students' interest click when I bring in real-life cases." Adds Thomas Bohan, founder and CEO of MTC Forensics, a technical forensics consulting business based in Maine, "Basically, we are trying to find out what happened in a crime or accident and why, which often comes down to determining who was responsible for someone's injury. We look in much more detail than you ever would if you were just teaching an elementary physics course." After earning a PhD in physics, Bohan went back for a law degree, and in 1982 he started his consulting business, through which he handles cases involving everything from auto accidents and gun crimes—including bullet trajectories and firing mechanisms—to fires, oil spills, and product liability.

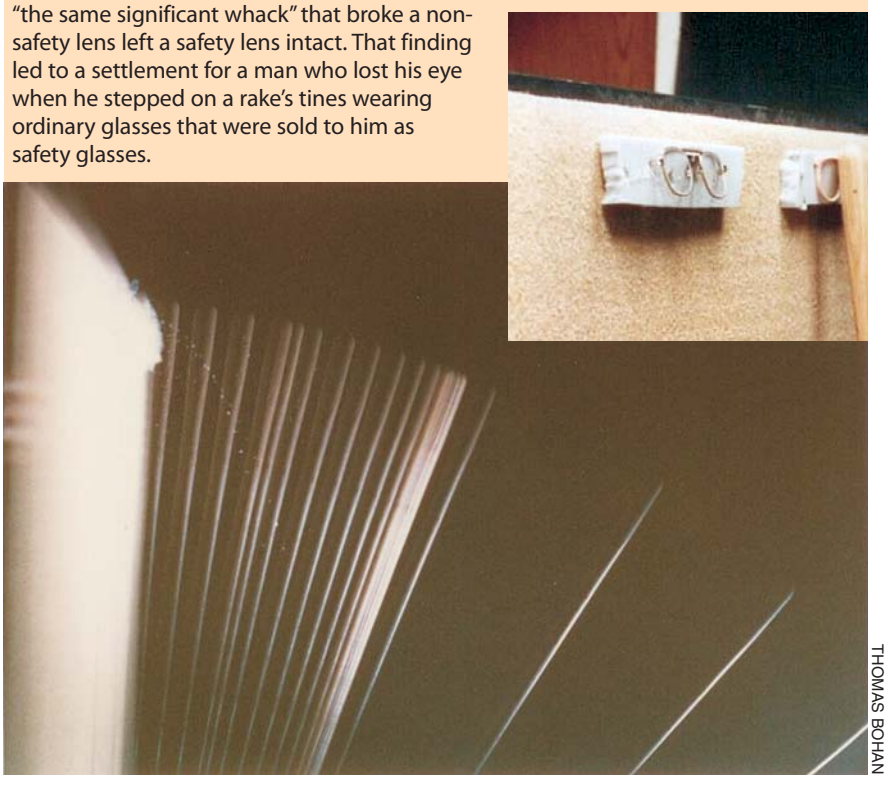
The physics tends to be straightforward—Newton's laws, thermodynamics, friction, and the like—although, says Bohan, "sometimes the application of these requires some subtlety." Involvement in a civil or criminal case typically starts with a phone call from a lawyer, police officer, coroner, insurance agent, or local or state government representative. Less often, calls come from a plaintiff or from a relative who believes a death was not an accident.

Consultants get police reports, witness statements, medical records, and photos, among other data. Another data source is the black boxes in cars. "Event data recorder information can be crucial to the forensic analysis," says Peter Alexander, a physicist at Raymond P. Smith and Associates, an accident forensics analysis company near Denver, Colorado, "but the EDR data can lie." As examples, he notes that EDRs have given impossible impact speeds, and have been known to report that the seatbelt was not buckled, yet photos show a dead victim with the seatbelt on.

Event reconstruction

In motor vehicle crashes, says Bohan, "you look at coefficients of friction, how tires slide on the road when a car goes around a corner too fast. If there was an abrupt large acceleration at impact, the

With strobe images of a rake handle hitting ordinary and safety glasses, forensics consultant Tom Bohan measured the speed at impact and showed that "the same significant whack" that broke a non-safety lens left a safety lens intact. That finding led to a settlement for a man who lost his eye when he stepped on a rake's tines wearing ordinary glasses that were sold to him as safety glasses.



THOMAS BOHAN

ROD CROSS

This cliff in Sydney, Australia, was the site of model Carolyn Byrne's 1995 death. A physicist's measurements and calculations helped convict Byrne's boyfriend of murder.

filaments of the lights—brake lights, tail lights, or turn-signal lights—may deform." If a light is on at impact, the filament may stretch, which is known as "hot shock." If the light is off, the filament may break—"cold shock." Filaments can provide crucial information, says Bohan.

"I look at the situation and see what the data is telling me," adds Dale Syphers, a physicist at Bowdoin College in Maine. "Sometimes I go straight to the site. I look at the debris fields, marks on the road, gouges in the road. There are all kinds of little things you pick up." In one case, he says, "a sheriff got a call about a four-year-old who was out of control. [The sheriff] sped to the house at something like 80 miles per hour. Another car made a left-hand turn, and the sheriff impacted the side in a T-bone and two young adults died. There was a very public trial, and eventually she was acquitted of negligent homicide." Syphers was asked by the attorney general's office to estimate the sheriff's speed. "It turned out that after the collision, [the sheriff's car] bounced up and down, leaving a series of brief skid marks. The bouncing is related to springs in the front suspension. As a physicist, I could look at [the data] and get more out of it." More, that is, than the state police or others who are trained in accident reconstruction but don't have a physics background, he adds. "They can only deal with a narrow range of situations. They can't look at something and figure out, using dynamics, kinematics, and Newton's laws, what exactly was going on." Syphers consults on around seven cases a year. "On a technical level they are fascinating, but one reason I don't do more is that I find them draining."

Reliable testimony

Bohan, author of *Crashes and Collapses: Essentials of Forensic Science* (Facts on File, due out this month), says, "My strongest interest is in establishing greater reliability for testimony in court and in the forensic conclusions on which litigation and prosecution are based. I've heard testimony from people who have fine credentials, whose statements don't pass the laugh test and yet have prolonged litigation for years. There is no way you can correct the damage that does." Adds Alexander, "Experts sometimes bring junk science into court with regards to auto reconstruction. The opposition gets 'expert testimony' to say the forces in a collision were benign—like flopping on an easy chair."

Bohan, Alexander, and others want the Supreme Court's 1993 *Daubert* ruling—that evidence be reliable—to be rigorously applied at trial. "That means the analysis procedure used is generally accepted in the field, testable, and has a quantifiable error," says Alexander. That aim may get a boost from the National Academy of Sciences, which at press time was planning a mid-February release of its report on the assessment of forensic techniques used in court proceedings. "I think the NAS report will constitute the dynamite needed to break down the wall preventing long-needed inquiries into the validity and error rates of a number of forensic techniques," says Bohan, listing infanticide inferred from retinal hemorrhages, fingerprinting, handwriting analysis,

and aspects of arson investigations as examples. The reason for the wall, he adds, "is that people who practice the techniques don't want them to be examined."

Still, the NAS report is broad, says Bohan, and as this year's president of the American Academy of Forensic Sciences, "I will push hard to have specific forensics techniques reviewed for reliability by an objective body such as the NAS so we can expel incompetent theories early in the legal process. One approach is to require expert witnesses to provide detailed written reports that can be peer reviewed."

Science out the window

"What I've learned," says Boise State University physicist Richard Reimann, "is that when you talk about injuries to children, science goes out the window, and emotions take over." He adds that "equations mean nothing to the general public, so now I am at the stage where it's got to be graphs or demonstrations."

Typically, Reimann gets called to determine whether a baby was shaken or hit, or whether an injury or death might have been from a fall. He recalls his first case, about a decade ago, when "a lawyer came walking into our offices looking for someone who could help him with head injuries. I reluctantly agreed to take a look." In that case a man reportedly woke up when he heard some thuds. He found the 11-month-old son of his girlfriend at the bottom of the stairway with a serious head injury. "The prosecutor's case was that the boyfriend hadn't been as quick [to call 911] as he said and that the injury couldn't have occurred by falling down the stairs—it had to have been some violent act like holding him by his ankles and swinging him against the bathtub."

But by Reimann's calculations, "even if a child were to topple over and hit his head on the floor, a skull fracture or brain injury was possible." And what really stuck with him, Reimann adds, "was the idea that the child had a low temperature when they took him to the hospital. I was able to get a couple of data points and to extrapolate back with Newton's law of cooling. It looked right spot on that the event could have happened five minutes before his call, whereas the prosecutor had it maybe an hour before." The judge threw Reimann's testimony out "because I was not a medical doctor," Reimann says. The man was convicted of murder in the first degree and sentenced to life without parole.

On other occasions, Reimann's testimony has helped the accused. In one case, "apparently one child was trying to take candy from an older child. He grabbed at it and fell over backwards. It didn't kill him, but he was injured. Authorities assumed the father did something violent, in spite of the fact that other adults were there." Reimann wrote to a local public defender explaining how to distinguish between injuries from shaking a baby and injuries from a head impact. Shaking is generally assumed when the retina has hemorrhaged, "but the medical community needs to look beyond that. If it was shaking, other organs would also be damaged," he says. "Ultimately, it's a physics or engineering issue," adds Bohan. "Is it possible to kill a baby just by shaking, without any evidence other than hemorrhages and subdural hematomas? No." Based partly on his letter, says Reimann, the father was let out of jail.

As for the cliff death in Australia, Cross determined that given the short run-up distance available, the victim could not have propelled herself as far from the cliff as she landed. The cliff is 30 meters high, and she was found almost 12 meters out. Cross did experiments with volunteers from a police academy, in which he measured how fast an average woman could run, jump, and dive. He also measured launch speeds by having men throw women into a swimming pool. "I tested a bunch of females, on flat surfaces, running uphill. . . . I spent a couple of years doing experiments—I did about 20 different experiments with 13 women," says Cross. "I worked out that she had to have been thrown."

Toni Feder

Accelerators shrink to meet growing demand for proton therapy

Smaller, cheaper accelerators promise to make proton radiation therapy available to more cancer patients.

The recent wave of newly constructed medical centers dedicated to proton radiation therapy comes as no surprise to James Slater, a radiation oncologist at Loma Linda University Medical Center. By 2010, four new US centers will start treating cancer patients. With two others that opened in 2006, that's more than double the number that had existed in the US in the first 15 years after Slater led the Southern California medical center in building the first hospital-based proton center in 1990. "I expected [this growth] to happen much sooner," he says.

In what may promise even more growth, some physics research labs and small companies are now developing room-sized proton accelerators to bring the treatment to existing medical centers. Those companies say their technology will supply a single treatment room for less than $30 million, a fraction of the $100 million to $200 million it now takes to build and equip larger proton centers. Treatments such as x-ray radiation and chemotherapy are still more available to cancer patients and less expensive than proton therapy. But x rays harm healthy tissue, and chemotherapy drugs weaken the immune system, among other things. Of late, many patients have been opting for proton therapy because of its minimal side effects when compared with the other treatments.

"Heavy lifting"

Protons penetrate human tissue to depths proportional to the incident energy, which for proton therapy ranges from 100 to 300 MeV. Because they have a relatively high mass, protons deliver

STILL RIVER SYSTEMS

Table-sized superconducting cyclotrons are being developed by Still River Systems for single-room proton-radiation treatment.