

## Mathematical pantyhose

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*This is another of the memoir installments of applied mathematician Ernst Gundar. Dr Gundar was Professor of Applied Mathematics at Clark's Nutcracker University (CNU) until his retirement in 1999. During this time he frequently consulted for businesses that required the skills of a mathematician.*

For five years during the late 1980s the Dean of Research at CNU was Morty Saltzman. I was never a big fan of Dr Saltzman but he did give the University a much higher research and development presence. He strived to promote the idea that a public university owed something to society. This generally meant motivating the faculty to do things for the public good. As Dean of Research he was particularly interested in consulting for local industry. His office frequently referred industrial representatives to me for some cheap advice. The Research Office handled all the paper work and billed their clients some trivial amount. Naturally, I didn't see any of this money. However, consulting was a good line item on my annual report.

One Monday morning, in the spring of 1986, I was just settling in to work at my office at CNU. I'd been away at a conference the previous week and was anxious to clean up the backlog of mail and memos that had accumulated on my desk so that I could get down to the real business of the day. There was a polite cough at my open office door. I swivelled my chair around to have a look.

"Yes," I said.

"Hello, Professor Gundar?"

I nodded.

"I'm Ralph Oberwetter."

The name didn't mean anything to me.

"From the Oberwetter Hosiery Company."

“I don’t need any socks right now.”

“I believe we have an appointment.”

Blank stare on my part. “Er, come in.”

The Research Office habitually sent people to me for consultation without informing me first. I didn’t like that but it’s best not to get on the wrong side of a Dean. Perhaps there was a memo in the unsorted pile of mail on my desk.

“Have a seat.”

“Dean Saltzman said you may be able to help us with our designs for a new product.”

I’d have to have a word with Saltzman about that later. I was up to my neck in unfinished projects and didn’t have time to take on anything new. Meanwhile, I couldn’t fault the customer for ending up in my office. The work that people brought to me was quite interesting and often led to other research on my part. So I put Saltzman out of my mind and resigned myself to hearing what Oberwetter had to say. I stood up from my desk, shook his hand, took a pad of paper and a pencil, and led him out to a meeting room where we usually entertained guests. There was no one else there. I settled him down with a coffee.

“What can I do for you?” He was about 50 years old, short and slightly round, with a healthy bald spot.

“We manufacture socks, stockings and pantyhose.”

“Uh huh,” I said, toying with my pencil.

“Currently, we have very successful lines of Tummy Control, Thigh Regulator, and Rump Retainer pantyhose.” He stopped to adjust his bow tie. “Now we want to develop pantyhose with bladder control.”

“Bladder control?” I put my pencil down and stared at him.

“That’s right. As you are most likely aware, pantyhose are worn almost exclusively by women.”

“Er.”

He leaned forward for a confidential whisper. “We sell plenty of pairs to football players, hydro linemen, police and others who require a thin, warm layer under their uniforms in winter. However,” he said, straightening up, “most of our clients are women. I’m sure you’ve noticed that women frequently go to the washroom.”

“I thought it was to powder their nose.”

“That’s the cover story. In reality they *tinkle*. At frequent intervals. In fact, more frequently than many of them would like.”

“Uh huh.”

“We’d like to create a pantyhose that will allow them to hold their bladder longer.”

“You mean waterproof.”

“No, no. Good gracious. The fabric must breathe. In fact, our Obertex 361 fabric is one of the most breathable on the market. If a woman were to wear air tight hosiery and she were to, er, pass wind, it could create quite a problem.”

“You’d get a fart balloon.”

“Precisely.”

“You could always collect the gas and then release it later, say on one of these frequent trips to the toilet you were telling me about.”

“Possibly. But what we have noticed in our research is that women urinate long before their bladder is actually full. If we could remove the *sensation* that the bladder was full then they could go much longer between—.”

“Between tinkles.”

“Correct.” At this point he brought out some drawings. “Perhaps if the nerves on this side of the bladder were compressed it would lessen the feeling that urination was necessary. You see, there is pressure on the bladder wall from inside due to the presence of the, er, fluid. If this was neutralized from outside with equal force provided by an elastic pantyhose of the correct size and shape, that might dampen, so

to speak, the desire to urinate. This would provide a sort of hydroseptic equilibrium. We have a few prototypes...” He reached into his bag and pulled out some nylons. “You see this panel here. Feel it stretch. It’s quite elastic.” He pushed it towards me but I recoiled. Ghostly legs dangled from a seamed crotch. Somehow, I didn’t want to touch these things.

“Look, what do you want me to do?”

“Well, you know about fluid mechanics, pressure and so on.”

I nodded.

“We’d like you to produce a mathematical model of the bladder wall and then help us design pantyhose so that they effectively balance the urine pressure.”

“Why don’t you make up ten different prototypes using different types of elastic material, say Obertex 100 up to Obertex 1000. Then hire a bunch of women and football players to test them out. You could even give them free coffee and Gatorade.”

“Oh, no. That wouldn’t work. It’s much more complex than you think. Our Thigh Regulator is made of 14 different types of fabric, with many convoluted, overlapping pieces. For the Bladder Tamer, with different styles and sizes, and types of fabric, and overlapping layers of various elastic panels, we would need to make several hundred test pairs and then have perhaps 100 women test each type. With thousands of experimental pairs in circulation we could never keep it a secret. Ours is a highly competitive profession, sir. With your help and a better mathematical model we could greatly reduce the number of prototypes needed for our tests.”

I agreed to look into it. He gave me a few more details and I sent him on his way with a half-hearted promise to talk with him again in three weeks. After he had gone I walked down to see Morty Saltzman. I caught him as he was stepping out of his office. I planted myself in his doorway so he couldn’t escape. “I’ve just met with the pantyhose guy.”

“Oberwetter.”

“He wants me to design pantyhose for him. Why did you send him to me?”

“Everyone else who knows about fluid dynamics was busy.”

“Everyone else was here to say no. I was away last week so you dumped him on me.”

“I’m sure you’ll be able to help him. Look, I’ve got to...” He eyed the doorway but I stood my ground.

“Morty, that’s nuts and you know it. Why don’t you send him to the Home Economics Department? Surely they have someone who specializes in clothing design.”

“That’s under a different Dean. Look,” he said as he patted me on the shoulder, “his firm has donated to our Outreach Scholarship Fund every year since the early 1970s. Humour him if you must but please don’t irritate him.”

I let him go and returned to my office.

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Three weeks later, I had Oberwetter back in the meeting room. By now classes had ended for the summer break and I’d gotten on top of most of the things I was involved in. It was standard procedure to do a preliminary study to see if a client’s project was feasible. If so, terms would be hammered out in the Research Office. We’d set up a rough schedule, see what resources we had, and find out what we’d need to purchase. A Research Coordinator would be appointed and they’d find undergraduates and graduate students to work on it. Some other faculty members might be coerced into joining. Students would get course credit or maybe a Master’s thesis out of it. If things went well it might lead to publications and other research. Everyone ends up happy. I’d been on several of these projects and generally they were highly rewarding. However, if the results of the preliminary study were not good, the client was sent packing.

“Well, Professor Gundar, what did you find out?”

“Mr Oberwetter, I’ve got two short demonstrations. I’ll do the first one myself. The Dean will be along in a few minutes to help us with the second one.” I pointed to various things on the table. “Over here I have some foam rubber chunks and some golf balls. I loosely fill this cloth bag with them and pull the draw string tight. We now have a cylindrical bag filled with foam and golf balls. It’s about the size of a chubby woman’s torso. Now I take this elastic girdle tube. It was designed to be worn around the abdomen after stomach surgery.” Oberwetter nodded. “Kindly hold your arms out so I can stretch the fabric over your hands. Good. There is plenty of room inside for me to insert the bag of golf balls and foam. Now release the girdle onto the bag.” He pulled his hands out and the surgical girdle compressed the bag nicely. “We go from a flabby midriff to something quite shapely.”

“But this is like our Tummy Control pantyhose.”

“Exactly. Think of the foam as the fatty tissue around the hips and abdomen. Fat is easily compressed. Under reasonable pressure, it can be shrunk by about ten percent. The oddly shaped pieces of foam leave lots of air pockets. The girdle squeezes out the air. This is like the interstitial spaces between the loosely packed organs in the body cavity. The golf balls model the bone and incompressible organs.” I pulled the bag out of the girdle and emptied everything onto the table.

“But we wanted...”

“Yes, for the Bladder Buster, or whatever you were going to call it, things are quite different. Notice the cushions we’re sitting on. They’re made of a firm but compressible foam, covered in fabric.” Oberwetter seemed puzzled but looked down at the cushion between his legs. “Notice that we have no difficulty compressing—.” At this moment, Morty Saltzman appeared in the doorway. “Ah, here’s the Dean to help us out with our second demonstration.”

We both stood up as he entered the room. Oberwetter and the Dean shook hands

and exchanged pleasantries. Saltzman then got interested in the bits of foam and elastic and golf balls lying on the table. He began to bubble on about how we must be making progress. Oberwetter and I sat down in our chairs and I gently pushed the remaining vacant seat towards Saltzman. Still babbling, he backed into his chair, which was some distance from the table. Suddenly, there was a loud *SQUOOSH* noise and a jet of fluid squirted out from between Saltzman's legs. When he jumped up we could see that his trousers were thoroughly soaked around the crotch. I darted forward and picked up a lank, dripping rubber bag from the seat of his chair.

"Thank you, Dr Saltzman, for helping us with our demonstration. When I fill a whoopee cushion with water and loosely seal the valve, I obtain a reasonable model of the human bladder." Saltzman looked down at his wet pants. "In this case filled with water. One difference between foam and water is that foam, like fat, is quite compressible whereas water, like you-know-what, is essentially incompressible. Hence, squeezing the water-filled whoopee cushion bag produced great stress on the valve, even though the material of the bag is quite elastic, like the walls of the human bladder." The Dean smiled weakly at Oberwetter. He glared at me and, still dripping, slunk out of the room.

I held out my hand to Oberwetter. "Sorry we weren't able to help you."

"Oh, you've saved us a lot of trouble. It's expensive designing new products. And that would have been—."

"Money down the drain." Oberwetter chatted amiably as I escorted him out of the building. After cleaning up the foam and other paraphernalia I hurried back to my office to pack. This was the start of the summer term. In a few hours I'd be flying off to Germany to collaborate on research with some old friends. I was also bringing the golf balls.

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*A word about CNU.* Clark's Nutcracker University was founded in 1851 by escaped Methodists. It is known for its extensive research in sound engineering in the early part of the 20th century and scientific computing beginning in the 1950s. The University is named after the Clark's Nutcracker (*Nucifraga columbiana*) which frequently nests in the pine forests surrounding the campus.