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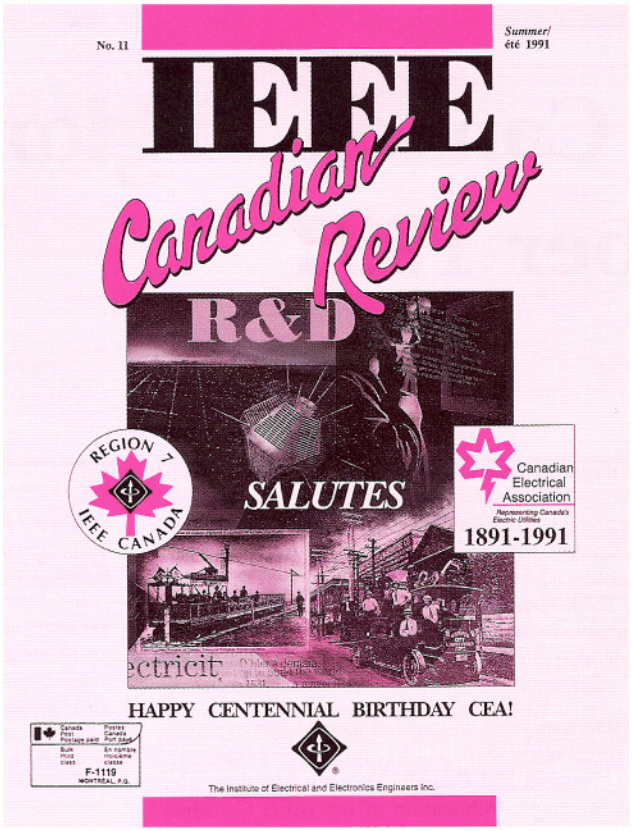

Happy centennial birthday CEA!

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Care, not speed

by Peter D. Taylor, Ph.D.
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One day last spring my daughter came home from school in a precarious mood. "I blew it, I failed, I couldn't possibly have passed, I didn't even answer half the questions, I never even got to the multiple choice. I am so mad I could scream!"

And, to her credit, she did.

"That does it: I'm gonna drop the course. Tomorrow I'm going in, and first thing I'm going to drop that course. I don't need it anyway. I'm not doing science I'm doing art, so I don't need it and I'm gonna drop it. Okay!?"

If that was a question to me, I wasn't given the chance to answer.

"What makes me so mad is that I know I can do the problems. I could do every one of them. I'm even good at them, I have good solutions, and I often think of really neat ways to attack a problem, you've told me that yourself".

She's right, I have.

"But when it comes to the test I'm hopeless. I can't begin to finish it. I can't even pass. I don't need this; I really don't. I'm dropping the course. A bunch of the girls say they're dropping too. It's stupid to hang in. Who needs a low mark?"

Well, I made soothing sounds, and I told her that exams were the pits but that we really didn't have a better way, and that I, her devoted father, knew she was good, so she shouldn't lose confidence just because of some stupid old test, but she was not to be consoled. At least I persuaded her not to drop the course until I had a chance to look at the test and maybe see what sorts of things we might work on. Anyway, I said, physics is important. What you're learning is good stuff. Just try to hang in a while longer.

This afternoon, I was just home and putting the kettle on, when she came in with the test. She had passed after all with a mark of 58%. But when the local university requires an average of 80 just to get in, 58 doesn't look so great. I settled down with my tea and toasted muffin, pen and pad of paper, and tried to put myself back 30 years to my grade 13 physics days. How long am I supposed to take? Seventy minutes. I set the minute minder on the microwave. Right. "Go!"

As I began the test, I was seized by all that old exam tension I had left behind years ago. "Read the question again; don't shoot from the hip, there might be a way to save some time, but don't ponder for too long; double check the tricky steps; keep it moving; don't get stalled."

The tea got cold, I hardly noticed the other kids come home from school, and before I knew it, the buzzer sounded. "Holy cow." Barely half done.

But it was fun; and some of the questions were really nice. (Tests are wonderful when they're not tests.) So I zapped the tea, grabbed a peanut butter cookie, and went upstairs to finish it off. It took me another seventy minutes. When I finished I had a new respect for my daughter. I don't think I had a 58 by half time.

I think I'd like to let you see the test. Don't they say you should occasionally sit down and watch what your kid is watching on TV? Well, maybe, just maybe, you ought to sit down now and then and find out what your kid is doing in her physics class. So here it is folks: grab your pencils and Do-si-do.

OAC Physics Test — Seventy minutes.

1. A dart is thrown horizontally directly towards the bullseye with a speed of 20 m/s. It hits the dart board 0.1 s later. How far below the bullseye does it hit?
2. A train starts from rest with constant acceleration, and reaches a speed of 20 m/s in 5 minutes. How far did it travel in the last minute?
3. A quarterback throws a ball due north at 12 m/s for an intended receiver running at 6 m/s west along a path 24 m from the quarterback. A wind of 1 m/s east is blowing which affects the football's flight. How far east of the quarterback should the receiver be when the ball is released?
4. A woman standing on top of a high cliff throws three balls: one straight up at 10 m/s, one straight down at 10 m/s, and one horizontally at 10 m/s. Which ball will hit the ground with the greatest speed? Neglect air resistance.
5. An object falls from a bridge that is 45 m above the water, and lands in a boat moving with constant velocity. If the boat was 12 m from the point of impact when the object was released, find the speed of the boat.
6. A parachute is released from an aircraft and at a given time is 300 m above the sea and 400 m north of a harbour. The chute is dropping at a constant speed of 15 km/h, and there is a 15 km/h wind blowing towards the northeast. A launch sets out from the harbour at this time to meet the chute as soon as it reaches the water. What is the direction and required velocity of the launch with respect to the water? (Neglect the effect of the wind on the launch and assume the water is at rest.)
7. An object is fired vertically upwards at "u"m/s. When it has reached 4/5 of its maximum height, its velocity is 20 m/s.

   (a) How high did it go?

   (b) What was its initial velocity "u"?

   (c) How long was it in the air?
8. A projectile is fired from a height of 20 m above the ground at an elevation angle of 40 degrees, and strikes the ground at a horizontal distance of 4000 m. How high was it at a horizontal distance of 3800 m?

9. A shell is fired from a height of 20 m above the ground at a speed of 100 m/s and at an elevation angle of 60 degrees.

   (a) At what horizontal distance does it strike the ground?

   (b) A rectangular mesa of height 380 m (above ground level) sits directly in the path of the shell. Suppose the shell just clears the edge of the mesa on its way up and again on its way down. How wide is the mesa?

10. A target missile is fired due north from ground level at a point A, with a speed of 600 m/s and an elevation angle of 30 degrees. Moments later, an intercepting missile is fired from ground level at a point B 4.5 km north of A, with a speed of "u"m/s and an elevation angle of 54 degrees.

    Calculate

    (a) the time of interception

    (b) the height of interception

    (c) the horizontal position of interception

    (d) the initial speed "u"of the second missile.

11. Two friends A and B are directly opposite one another on opposite banks of a 200 m wide river which flows at a uniform speed of 3 km/h. A, who has a boat and who can row at a speed of 4 km/h (in still water), set out to cross the stream at the same instant as B begins to walk along the bank in the downstream direction at a steady speed of 6 km/h.

    (a) At what constant angle to the bank must A head his boat so he meets B just as he arrives at the bank.

    (b) When do they meet?

    (c) How far does A travel relative to the bank?

12. Base B is 400 km N30E of base A. Plane B takes off from base B and heads due south at 250 km/h. At the same moment, plane A takes off from base A at a speed of 400 km/h, to intercept plane B. If the wind is from the east at 80 km/h, where and when does the interception take place?

(PLUS: Ten multiple-choice questions)

Nice questions eh? Some are fairly straightforward, but others, like 8, 9 and 10, require the solving of complicated equations. All the problems seem to need a few moments of reflection time just to set things up properly, and problems like 2 and 4 are quite discriminating in that some preliminary thought can lead to quite an elegant solution. So it's not a simple test, even if you have the equations of motion at your fingertips. My daughter tells me there were a couple of young men who got above 90. I find that quite impressive.

My purpose is not actually to talk about the test itself, but about a generally held view of science that this test epitomizes so well. But I should say first that I have absolutely no quarrel with the teacher who set it. It is certainly too long for most of the students in his class, but all teachers, and I am as guilty as anyone, set such tests from time to time. And, especially in the final year of high school, the teacher surely has a duty to prepare the students properly for future studies. My nephew has just finished his second-year in Engineering Physics at Queen's, and he assures me that his physics exams require a high level of rapid problem-solving ability.

What I do want to talk about is the discouraging effect that this test, and a whole history of others like it, have had on my daughter. She possesses a good mind, and over the years, I have observed that she has a real talent for problem-solving. But she is now, at the end of her high school career, convinced that there is no real place for her in the scientific community, and, in any event, that it would be sheer folly for her to study science in university, because she simply couldn't pass the exams. In fact I am not unhappy with her current desire to study fine arts, though I do think she would make a good scientist. What worries me is that there may be a large number of students like her, who really do want to pursue a career in science or engineering, but who are discouraged from doing so by current educational attitudes and practices.

Here's the point:

The way we teach and examine science both in school and in university puts a huge premium on the ability to solve problems quickly, and I don't think that's really such an important part of being a scientist/engineer. Indeed, more than ever, I think we need to be producing scientists who are more thorough, more careful, and more caring about what they do and how they do it.

In school today, in physics and in math, it's not how well you do your work but how quickly you do it that counts. This is certainly true when it comes to the exam, which is, of course, the bottom line of our evaluation process. But I think it's also true during the school year, when there might appear to be lots of time for an emphasis on high-quality work. Students seem to have a bewildering collection of jobs and social encounters to negotiate, curricula are more packed than ever with apparently important technical skills, and under semestering, a new idea comes relentlessly every single day. A student who works slowly, who needs (craves?) the time to savour one concept before moving on to the next will simply not get the work done, will fall behind, and eventually, will fall away.

The reason that there is not an enormous concern about this problem in the academic community is, I think, that a considerable number of those students who take pride in the quality of their work, also respond in a very positive way to the challenge of doing it quickly. There are enough such students around that they are a visible presence in any classroom, and the teachers and the other students notice them, and conclude that they are the obvious ones to become the scientists/engineers of the future. But I'm sure there is also a substantial group of students whose quality of work and standards of excellence are just as high, and who respond very negatively to the challenge offered by this test, who are in fact—though they may not have the wisdom to acknowledge this—insulted by it. And that's the reason I wanted to reproduce the test here. I want you to at least look at it and think about what it might feel like to have to sit down and write it. There really are two ways to respond. One is to feel challenged, as I and most of the scientists/engineers of my generation were when we were in school, and to rise to the occasion. The other is to feel cheated, subverted by a game you don't really want to play, whose importance, deep down, you may seriously question.

The tragedy of this is that not only might these "other" students become good scientists or engineers, they might just become, for the real needs of tomorrow's society, the best scientists we have; indeed, a measured careful pace, an attention to detail, and a consideration of the greater implications of a project, is perhaps needed now more than ever. In the final analysis, how fast you manage to do things doesn't matter in science one bit. Quite the reverse: those who manage to grasp the right piece of the puzzle are those who are able to slow themselves down at just those crucial points where everyone else has always gone whizzing round the corner.

And I also can't help but wonder whether there might be more women in this slow-and-careful category than men. Certainly I think that science today really needs the woman's particular way of understanding the world. And those in high places must think that too, because at the moment they are spending great sums of money trying to encourage more women to study science. A good place for them to start looking might be this test.

Peter D. Taylor, Ph.D. is a Professor of Mathematics at Queen's University, Kingston, Ontario. This article was first published in the Kingston Whig-Standard.