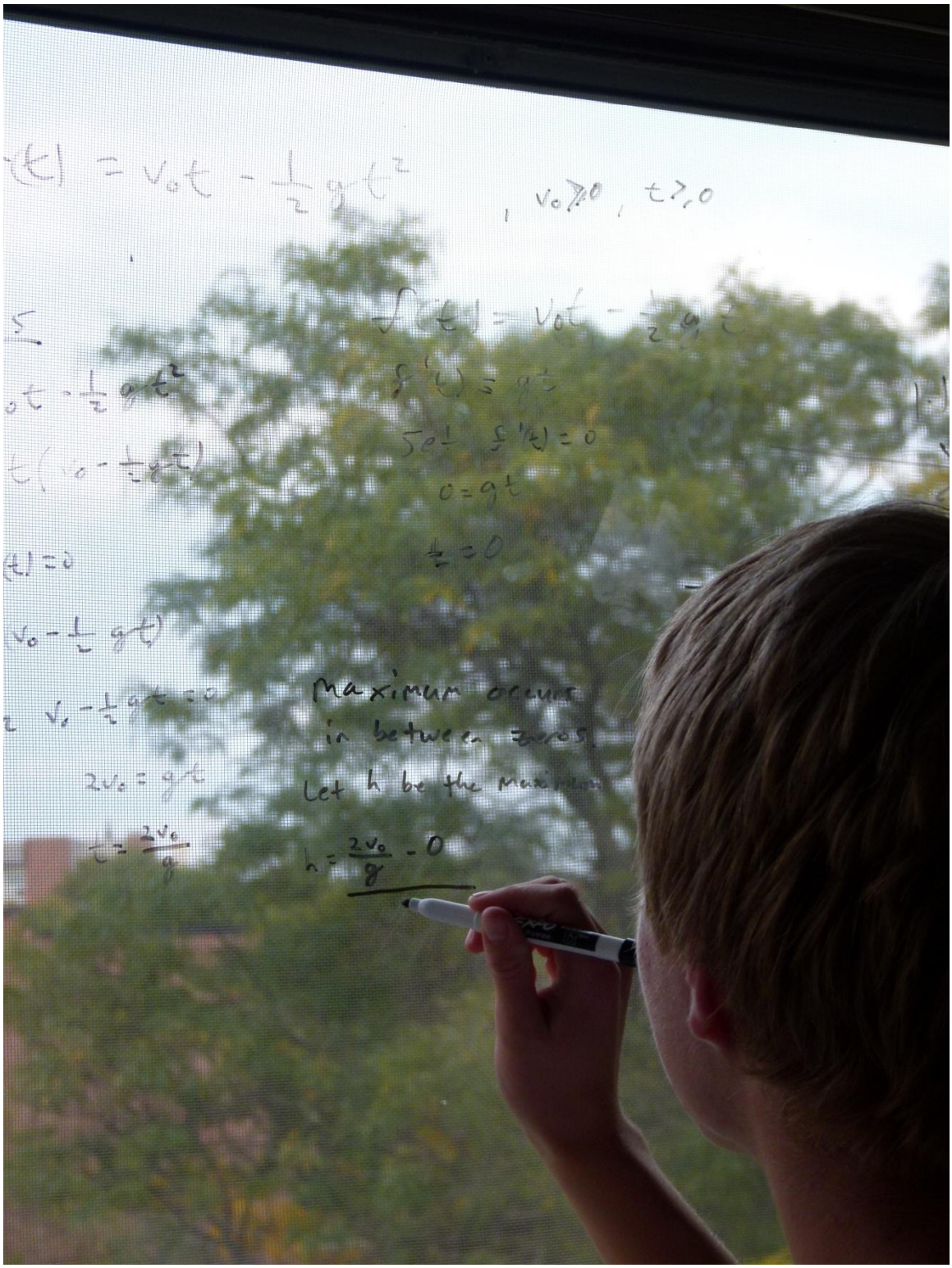
# dark matter

**vol. 1 fall 2011 term**



## Execs Are People Too

### First Year Rep
Shane Lawrence

To first year Physics/ Mathematical Physics/ Chemical Physics students—we can all take a sigh of relief, for we have finalll made it to the University of Waterloo. As we go through our undergraduate degree at one of Canada's top universities, the executive of PhysClub want to make your studying experience as enjoyable as possible, and would like to do anything to eliminate all the unnecessary stress that may occur.

I am in first year Mathematical Physics, and I am certainly already feeling some of the stress that each of you is probably experiencing. Remember that there are quite a few people who are willing to help, whether they are the dozens of peers in your program or the students in 4th year who wish they had someone to give them advice in their first term. Don't be afraid to ask for help if you have trouble with concepts, questions, or stress.

If you find you are having any problems relating to physics or your program—ANY problem at all—you can contact me at shane_len7@hotmail.com. I hope to be an excellent first year rep to PhysClub who can relate first year problems accurately to the exec as a whole.

Shane Lawrence
First Year Representative

## Resultant Hilarity

### does not commute – Stefan De Young

If you've taken PHYS 234, then you've analysed the quantum simple harmonic oscillator.

$$E_n = \hbar\omega(n+\tfrac{1}{2}) \; ; \; n = 0, 1, 2\ldots$$

So there are $|n\rangle$ quantum states, each with its own energy. We are able to climb to the next higher energy level with the construction operator $a_+$ and move to lower levels with the destruction operator $a_-$. We call these ladder operators.

$$a_+|n\rangle = \sqrt{n+1}\,|\,n+1\rangle$$
$$a_-|n\rangle = \sqrt{n}\,|\,n-1\rangle$$

In assignment 1 of PHYS 434, we were looking at an anharmonic oscillator with a Hamiltonian

$$H \propto (a_+ + a_-)^4$$

Expanding, we'll end up with terms like $a_- a_+ a_- a_+$. These cannot be written as $a_-^2 a_+^2$ because $a_-$ and $a_+$ do not commute. Consider the following:

$$\langle n|a_- a_+ a_- a_+|n\rangle = \langle n|a_- a_+ a_-|n+1\rangle\sqrt{n+1} = \langle n|a_- a_+|n\rangle(n+1) = \langle n|a_-|n+1\rangle(n+1)^{\frac{3}{2}} = \langle n|n\rangle(n+1)^2 = (n+1)^2$$

BUT

$$\langle n|a_-^2 a_+^2|n\rangle = \langle n|a_- a_- a_+ a_+|n\rangle = \langle n|a_- a_-|n+1\rangle\sqrt{n+1} = \langle n|a_- a_-|n+2\rangle\sqrt{n+2}\sqrt{n+1} = \langle n|n\rangle(n+1)(n+2) = (n+1)(n+2)$$

Ladder operators do not commute.

## punchlines

A photon checks in to a hotel and is asked if he needs any help with his luggage. The photon replies, "No thanks, I'm travelling light."

Tyler Brown

## Prof Quotes

"Because nothing travels faster than the speed of light, right?"

-Dr Gunter Scholz

"You're always welcome to participate [in class] just as long as I remain firmly in control of the conversation."

-Taylor

"You guys are 4th years: a sophisticated, worldly audience. You may spend a lot of time at cafes. I don't know."

-Taylor

dark matter is edited by Emma McKay
and all contributions are made by physics students just like you
contribute to the next edition: uwdarkmatter@gmail.com