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Dear Committee:

I am happy to write this letter to strongly recommend Ms. Tori Luongo for a SMSS undergraduate award. Tori is in her 3<sup>rd</sup> year as an (honors) undergraduate Mathematical Sciences major, but still somehow is a senior who will graduate this summer. She is also in the BS/MS program, and will formally start in the MS program in the fall. Every year, we tend to have 1 or 2 real superstars graduate from our undergraduate program – this year Tori is certainly one of these students.

Regarding coursework, Tori has a 4.0 GPA and has taken almost all of the “hard” undergrad courses including advanced calc I and II, and has also taken 3 graduate courses – she got A’s in 8000, 8100 and 8600 (and I note Timo did not give many A’s in that 8600 section). I repeat again that she is only in her 3<sup>rd</sup> year right now, and her first year she did during covid with all the terrible zoom courses. For coursework, this puts her about even with Sloan Nietert and Ben Cousins, who were two of the best ug MathSci students Clemson has ever had in (if you’re the best in MathSci, probably you are just the best for all majors).

Tori got involved with undergraduate research during her 2<sup>nd</sup> year as an undergraduate, taking Irina’s CI course and working with Irina and some mechanical engineers on an interdisciplinary problem involving heat generation due to cyclic load in viscoelastic materials. Basically, they students how vibrations can cause enough heat to make certain materials fail, e.g. materials used in hip replacements. This involved mathematical modeling (developing the PDE model) and also hands on lab work. Tori did very well at this, and presented the work at Clemson Catalyst competition in spring 2022 (her team won 3<sup>rd</sup> place which gave her full summer funding to continue CI research in summer 2022), and then at the 7<sup>th</sup> North American



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Conference on Industrial Engineering and Operations Management in summer 2022 (where her presentation won 1<sup>st</sup> place).

Tori began working with me in January 2022, first just meeting every couple weeks to discuss some equations that come up from her work with Irina and how to numerically solve them. While at first I thought this would be rather straightforward, there turned out to be some subtleties that were not so easy to handle – for anyone, much less an undergraduate. By mid spring, we were meeting weekly and by mid summer she was working exclusively with me (after her presentation was done). The equation she was working on with Irina was essentially a type of Fujita equation (semilinear heat equation), and the challenges were to determine how to develop an efficient and stable time stepping method, as well as determine whether the Newtonian relaxation term was negligible (which the engineers said it was not, but we found was very important). Tori ended up solving the problem, developing an efficient method and proving it was stable under certain conditions on the time step size and for certain problem data – but that blow up could happen under other problem data (which is known to happen physically, as the blow up corresponds to material failure). The proof was very nontrivial, and probably more complex than any numerical stability proof any of my PhD students has ever done. It starts with energy type arguments, but then needs induction and very careful, technical analysis using Holder inequality, Sobolev inequalities,  $L^p$  norms,  $H^k$  norms, Gagliardo-Nirenberg inequality, and Agmon's inequality. Putting all these pieces together is something that a good comp math PhD student who is about to graduate can usually do. But Tori did it in her 3<sup>rd</sup> year as an undergraduate. Oh, and she did numerical simulations of her method to solve this nonlinear PDE which illustrated / “verified” (engineers say verified, but really the proof is the verification) her results and the stability regions her analysis predicted. She is in the process of writing this up, and she will submit it to SIAM undergraduate journal (it could easily publish in a solid numerical journal, but with Tori if it's not going to the absolute top journals then I don't think it belongs on her resume). She will be presenting her work this spring at the Nebraska women's mathematics conference in February as well as the AMS meeting at Georgia Tech.



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Lastly, I want to say that she is just such a nice person, so humble, and such a pleasure to work with. I don't know where we found her, but we need to find more just like her.

In my opinion, she is as good as any undergraduate math major I have seen come through, and I think at the level of Ben Cousins or Sloan Nietert. She has produced in the classroom but more importantly with undergraduate research that is really just "research", there is nothing undergraduate about it except that she is an undergraduate. She has my full and strong support for the highest award the SMSS gives out.

Please don't hesitate to contact me if you have any questions.

Sincerely

A handwritten signature in black ink that reads "Leo Rebholz". The signature is fluid and cursive, with a long horizontal stroke extending from the end.

Leo Rebholz



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