A procedure for developing a first draft of an abstract

1. Start by answering the following questions:

a) If I only had two sentences to convey the big picture message, what would I write?

b) What is the relevant context for this work? That is, how does it relate to larger concepts?

c) What are the essential facts that distinguish this work? This means: make a list of sentences but don't worry about stringing them together yet. Better if they are completely separate.

2. Separate all of your sentences with an open line. Look for ones that are irrelevant, terribly written, or redundant and eliminate them. If you cut a bad sentence that contains necessary information you may want to try rewriting it. Do some light editing of sentences that could obviously use some work, but don't invest much effort in this because you will almost certainly change them once they are positioned in relation to the other sentences.

3. Assemble the remaining sentences in an order that has some logical flow to it, and only after you believe that you have a good logical order, push them together in a paragraph.

4. Examine the paragraph overall, generally working from top to bottom. Don't be afraid to cut a sentence at this point and insert something new if what you have doesn't work. Why should it? You wrote these as standalone ideas, and perhaps they need to be entirely reworked to get them in a good form to place nicely with the other sentences.

5. Continually assess the writing in light of big goal defined by your answers to questions A and B. If it does not address those points, find what you have lost and fit it back in.

6. Repeat steps 4-5 until the abstract converges to something readable. You should have no more than 10 sentences, and if you write well, half that should suffice. You may have a decent first draft when your answers to the following questions are all "yes".

a) Does my abstract establish context?
b) Does my abstract clearly state the specific findings, results, or conclusions?
c) Are the essential details presented in a way that enables the reader to understand the importance of the work?
d) Would you use the words "brief" and "efficient" as descriptors of your abstract?

Becoming a good writer requires that you become a critic.
Be ruthless with your work.

Example of an iterative abstract development:

Note: the full record of iterations is kept here only to demonstrate the process. You wouldn't do this in practice. You would simply edit as you normally do, but using the above procedure for iterating to a working draft.

Part 1:

Answer to question a:
A new device has been constructed that is unique in its ability to model wave propagation in inhomogenous media, as might be found in quantum and plasma systems. These experiments are a great pedagogical arena for students to confront problems of complex wave propagation exhibiting reflection, evanescence, and dispersion, among others.

Answer to question b:
This work builds on previous studies in experiments that showed wave cutoff effects, but the varying length of pendula in this experiment allows us to model nonuniform potentials.

Answer to question c:

- A system of coupled pendula can exhibit a wide range of behavior on account of the fact that the group and phase velocities need not be the same.
- The driver in this system is substantially larger than that used in previous experiments and does not suffer from impedance matching issues.
- A driven, coupled-pendula experiment has been developed, and is unique in comparison to prior devices in that it uses pendula length that can be adjusted for each mass.
- The masses and springs are uniform.
- This variable length pendula allow for a local dispersion relation which can be imaginary.
- The frequency of the system is fixed by an external driver of fixed amplitude.
- The combination of imaginary dispersion relation and fixed frequency then implies the system will develop evanescent wavelengths.
- This can be interpreted as an analogy for quantum mechanical tunneling through forbidden regions and evanescent electromagnetic waves in plasma systems.
- These experiments represent a good pedagogical experiment that enables undergraduate students to see wave tunneling and other "quantum" effects.

Part 2:

<u>Iteration 1</u> (rough editing, cutting and elimination of redundant sentences)

A new device has been constructed that is unique in its ability to model wave propagation in inhomogenous media, as might be found in quantum and plasma systems.

These experiments are a great pedagogical arena for students to confront problems of complex wave propagation exhibiting reflection, evanescence, and dispersion, among others.

This work builds on previous studies in experiments that showed wave cutoff effects, but the varying length of pendula in this experiment allows us to model nonuniform potentials.

~~The driver in this system is substantially larger than that used in previous experiments and does not suffer from impedance matching issues.~~ Note: this sentence is unnecessary, can be included in the paper and is not necessary at this level.

A system of coupled pendula can exhibit a wide range of behavior on account of the fact that the group and phase velocities can differ.

~~A driven, coupled-pendula experiment has been developed, and is unique in comparison to prior devices in that it uses pendula length that can be adjusted for each mass.~~ Note: this sentence is redundant with the first and third, so we will just cut it now.

~~The masses and springs are uniform.~~ Note: doesn't add anything significant, cut it.

~~This variable length pendula allow for a local dispersion relation which can be imaginary.~~ Note: also redundant. The part about an imaginary solution is somewhat relevant, but probably does not need to be presented in the abstract, that is more of a detail that can be presented in the full analysis. The description of tunneling is effectively equivalent.

~~The frequency of the system is fixed by an external driver of fixed amplitude.~~ Note: this is a terrible sentence -notice that the word "fixed" is repeated. It is also just uninteresting. Let's replace it with the following:
The properties of the system were studied as a response to a constant amplitude driver that was operated at different frequencies.

~~The combination of imaginary dispersion relation and fixed frequency then implies the system will develop evanescent wavelengths.~~ Note: also redundant.

This can be interpreted as an analogy for quantum mechanical tunneling through forbidden regions and evanescent electromagnetic waves in plasma systems.

These experiments represent a good pedagogical experiment that enables undergraduate students to see wave tunneling and other "quantum" effects.

Iteration 2 (now try to place the remaining ones in a decent order)

A system of coupled pendula can exhibit a wide range of behavior on account of the fact that the group and phase velocities can differ.

This can be interpreted as an analogy for quantum mechanical tunneling through forbidden regions and evanescent electromagnetic waves in plasma systems.

~~These experiments are a great pedagogical arena for students to confront problems of complex wave propagation exhibiting reflection, evanescence, and dispersion, among others.~~ Note: this sentence looks redundant now, and it's not as good as the others: "pedagogical arena" is not good writing, sounds cliché. Get rid of the whole thing.

This work builds on previous studies in experiments that showed wave cutoff effects, but the varying length of pendula in this experiment allows us to model nonuniform potentials.

~~A new device has been constructed that is unique in its ability to model wave propagation in inhomogenous media, as might be found in quantum and plasma systems.~~ Note: this sentence is also redundant.

The properties of the system were studied as a response to a constant amplitude driver that was operated at different frequencies.

These experiments represent a good pedagogical experiment that enables undergraduate students to see wave tunneling and other "quantum" effects.

Iteration 3 (see if it works as a paragraph, and add connectors if necessary)

A system of coupled pendula can exhibit a wide range of behavior on account of the fact that the group and phase velocities can differ. This can be interpreted as an analogy for quantum mechanical tunneling through forbidden regions and evanescent electromagnetic waves in plasma systems. This work builds on previous studies in experiments that showed wave cutoff effects, but the varying length of pendula in this experiment allows us to model nonuniform potentials. The properties of the system were studied as a response to a constant amplitude driver that was operated at different frequencies. These experiments represent a good pedagogical experiment that enables undergraduate students to see wave tunneling and other "quantum" effects.

Iteration 4 (revise again)

A system of coupled pendula can exhibit a wide range of behavior because the group velocity and phase velocity can be different, resulting in a wide range of effects such as wave dispersion, reflection and tunneling. This can be interpreted as an analogy for quantum mechanical tunneling through forbidden regions and evanescent electromagnetic waves in plasma systems. This work builds on previous studies in experiments that showed wave cutoff effects, but the varying length of pendula in this experiment allows us to model nonuniform potentials. The properties of the system were studied as a response to a constant amplitude driver that was operated at different frequencies. These experiments represent a good pedagogical experiment that enables undergraduate students to see wave tunneling and other "quantum" effects.

Iteration 5 (and again)

A system of coupled pendula has, in general, group and phase velocities that differ. This implies that a rich range of dynamics can be observed in such systems, including wave dispersion, evanescence, and tunneling. These effects can be interpreted as an analogies for quantum mechanical and plasma systems. This work builds on previous studies in experiments that showed wave cutoff effects, but the varying length of pendula in this experiment allows us to model nonuniform potentials. The properties of the system were studied as a response to a constant amplitude driver that was operated at different frequencies. These experiments represent a good pedagogical experiment that enables undergraduate students to see wave tunneling and other "quantum" effects.

Iteration 6 (and so on)

A driven, coupled-pendula experiment with variable length pendula, and otherwise uniform characteristics, presents a system in which various wave phenomena, including dispersion, reflection and tunneling can be observed. These effects arise because the difference in natural frequencies of the pendulum and coupled oscillator parts create phase and group velocities which, in general, are different. This work builds on previous studies in experiments that showed wave cutoff effects, but the varying length of pendula in this experiment allows us to model nonuniform potentials. The properties of the system were studied as a response to a constant amplitude driver that was operated at different frequencies. These experiments represent a good pedagogical experiment that enables undergraduate students to see wave tunneling and other "quantum" effects.

Iteration 7

A driven, coupled-pendula experiment with variable length pendula, and otherwise uniform characteristics, presents a system in which complex wave phenomena can be observed. Effects such as reflection, tunneling, and wave dispersion arise because the difference in natural frequencies of the pendula and elastic oscillator components need not be the same, leading to phase and group velocities that, in general, differ. This work builds on previous studies in experiments that showed wave cutoff effects, but the varying length of pendula in this experiment allows us to model nonuniform potentials. The properties of the system were studied as a response to a constant amplitude driver that was operated at different frequencies. These experiments represent a good pedagogical experiment that enables undergraduate students to see wave tunneling and other "quantum" effects.

Iteration 8

A driven, coupled-pendula experiment with variable length pendula, and otherwise uniform characteristics, presents a system in which complex wave phenomena can be observed. Effects such as reflection, tunneling, and wave dispersion arise because the difference in natural frequencies of the pendula and elastic oscillator components need not be the same, leading to phase and group velocities that, in general, differ. ~~This work builds on previous studies in experiments that showed wave cutoff effects, but the varying length of pendula in this experiment allows us to model nonuniform potentials. The properties of the system were studied as a response to a constant amplitude driver that was operated at different frequencies.~~ An experimental device using a fixed amplitude driver has been developed as a pedagogical tool for the study of complex wave phenomena. These experiments represent a good pedagogical experiment that enables undergraduate students to see wave tunneling and other "quantum" effects.

Iteration 9

A driven, coupled-pendula experiment with variable length pendula, and otherwise uniform characteristics, presents a system in which complex wave phenomena can be observed. Effects such as reflection, tunneling, and wave dispersion arise because the difference in natural frequencies of the pendula and elastic oscillator components need not be the same, leading to phase and group velocities that, in general, differ. An experimental device using a fixed amplitude driver has been developed as a pedagogical tool for the study of complex wave phenomena. Experimental data from uniform and nonuniform conditions is compared against theoretical models using a WKB interpretation, and interpreted as analogs of quantum tunneling and propagation of electromagnetic waves in plasmas.

Iteration 10

A driven, coupled-pendula experiment with variable length pendula, and otherwise uniform characteristics, presents a system in which an interesting range of wave phenomena can be observed. Effects such as reflection, tunneling, and wave dispersion arise because the natural frequencies of the pendula and elastic oscillator components need not be the same, leading to phase and group velocities that can, in general, exhibit significant spatial variation. ~~An experimental device~~ A system of 22 coupled pendula driven by a constant amplitude driver has been developed as a pedagogical tool for the study of complex wave phenomena. Experimental data from uniform and nonuniform conditions is compared against theoretical models using a WKB interpretation, and interpreted as an analog for quantum tunneling and propagation of electromagnetic waves in plasmas.

Iteration 11

An array of coupled-pendula with variable length pendula can exhibit a broad range of wave phenomena. Wave reflection, tunneling, and dispersion arise because the natural frequencies of the pendula and elastic oscillator components need not be the same, leading to phase and group velocities that can, in general, exhibit significant spatial variation. A system of 22 coupled pendula driven by a constant amplitude driver has been developed as a pedagogical tool for the study of complex wave phenomena. Experimental data from uniform and nonuniform conditions is compared against a theoretical model ~~of waves~~ using a WKB formulation, and are interpreted as analogs for quantum tunneling and the propagation of electromagnetic radio-frequency waves in tokamak plasmas.

Working first draft

An array of coupled-pendula with individually variable lengths can exhibit a broad range of wave phenomena. Wave reflection, tunneling, and dispersion arise because the natural frequencies of the pendula and elastic oscillator components need not be the same, leading to phase and group velocities that can, in general, exhibit significant spatial variation. A system of 22 coupled pendula driven by a constant amplitude driver has been developed as a pedagogical tool for the study of complex wave phenomena. Experimental data from uniform and nonuniform conditions is compared against a theoretical model using a WKB formulation. The observed wave structures are interpreted as analogies for quantum tunneling and the propagation of electromagnetic radio-frequency waves in tokamak plasmas.

Final note: This abstract is a first draft and will be revised again before going to publication, probably at least twice. I can already see places where it needs work. The point, however, is that it is now good enough, feeling coherent and crisp, that it will work as starting point to guide the rest of the manuscript.