FRIEDRICH-ALEXANDER
UNIVERSITÄT
ERLANGEN-NÜRNBERG

NATURWISSENSCHAFTLICHE
FAKULTÄT

Modeling, Simulation, and Optimization (practical course)

Summer term 2019

Florian Frank and Günther Grün

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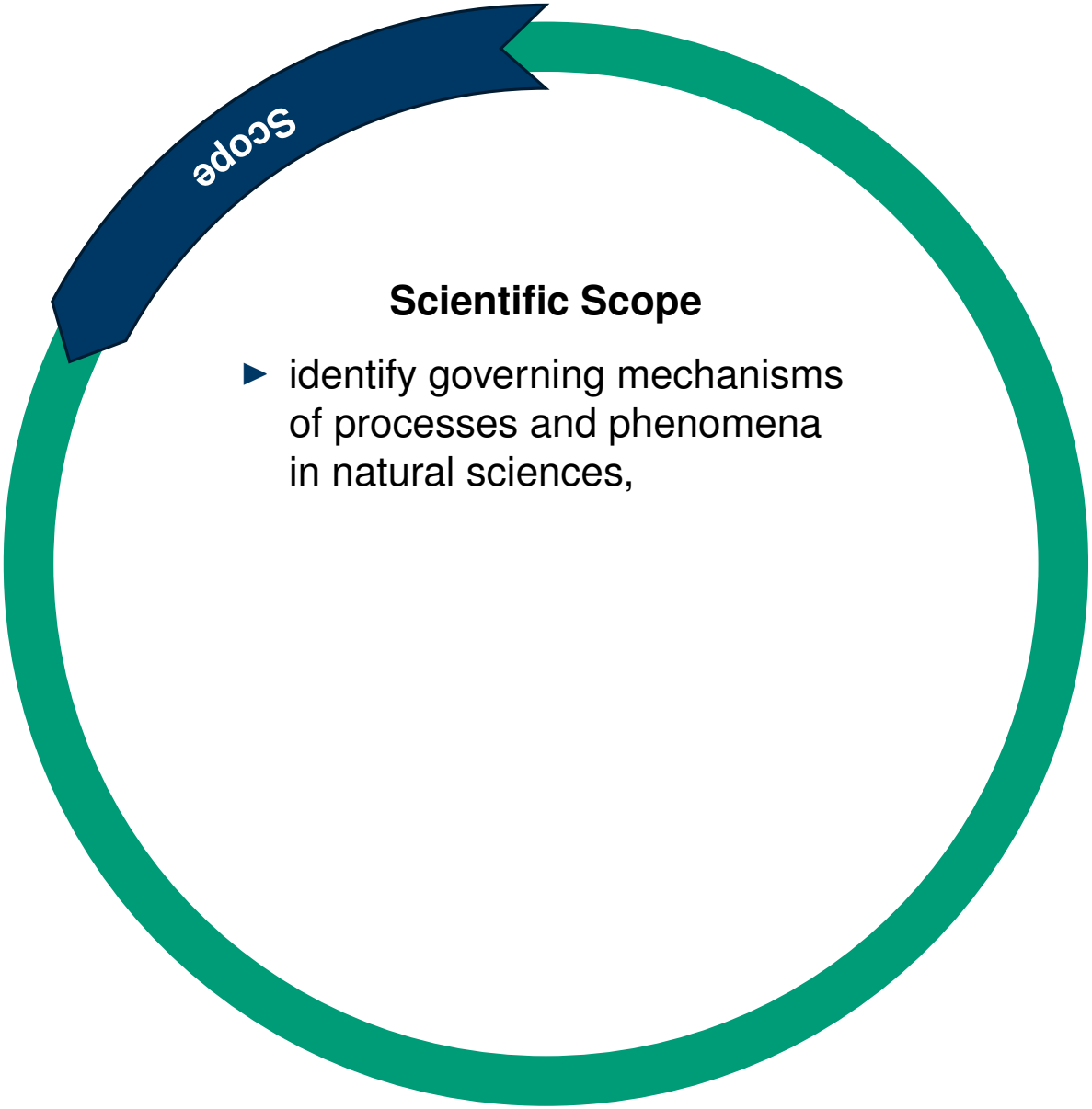
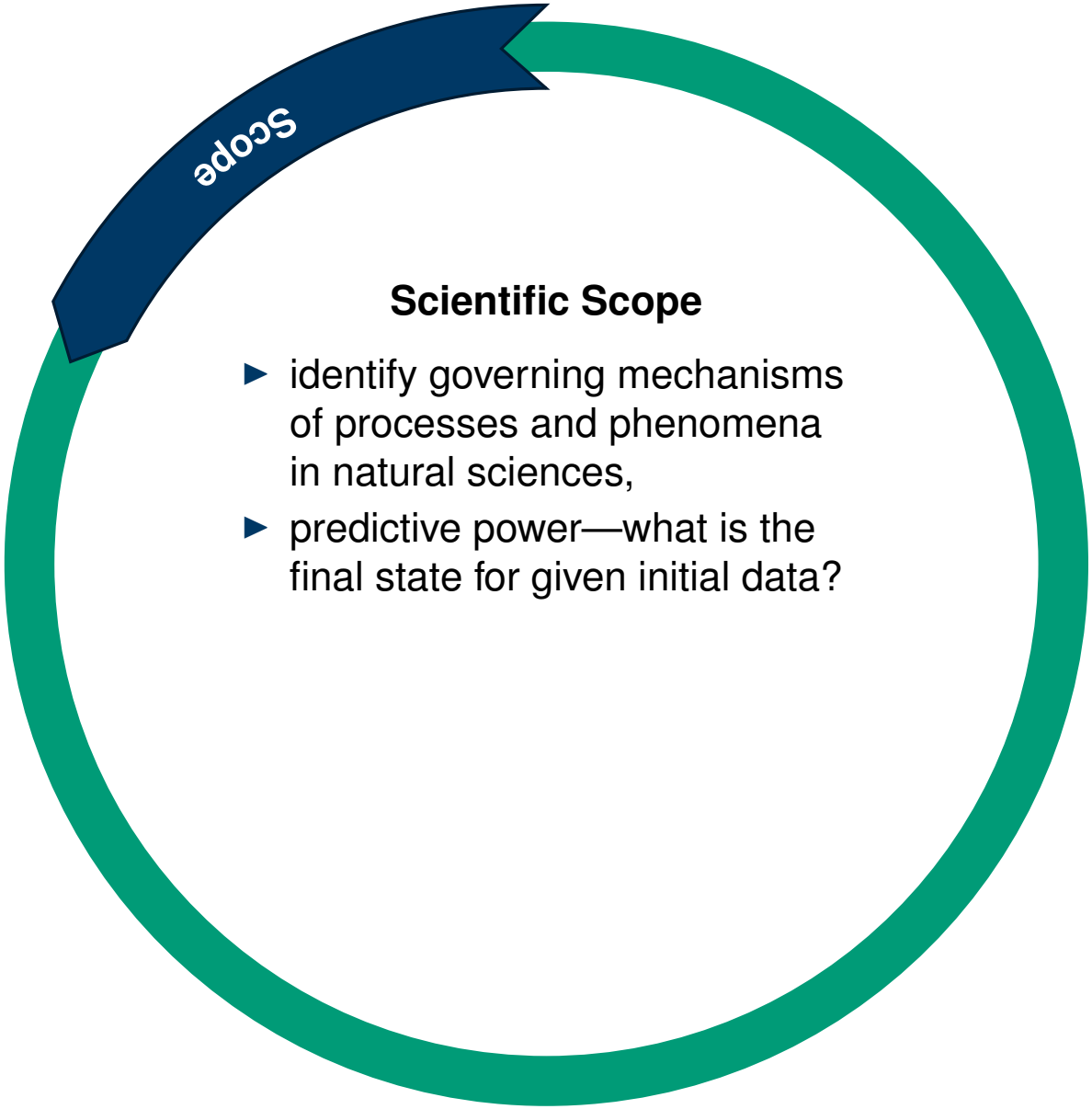
April 23, 2019



Scientific Scope

- identify governing mechanisms of processes and phenomena in natural sciences,



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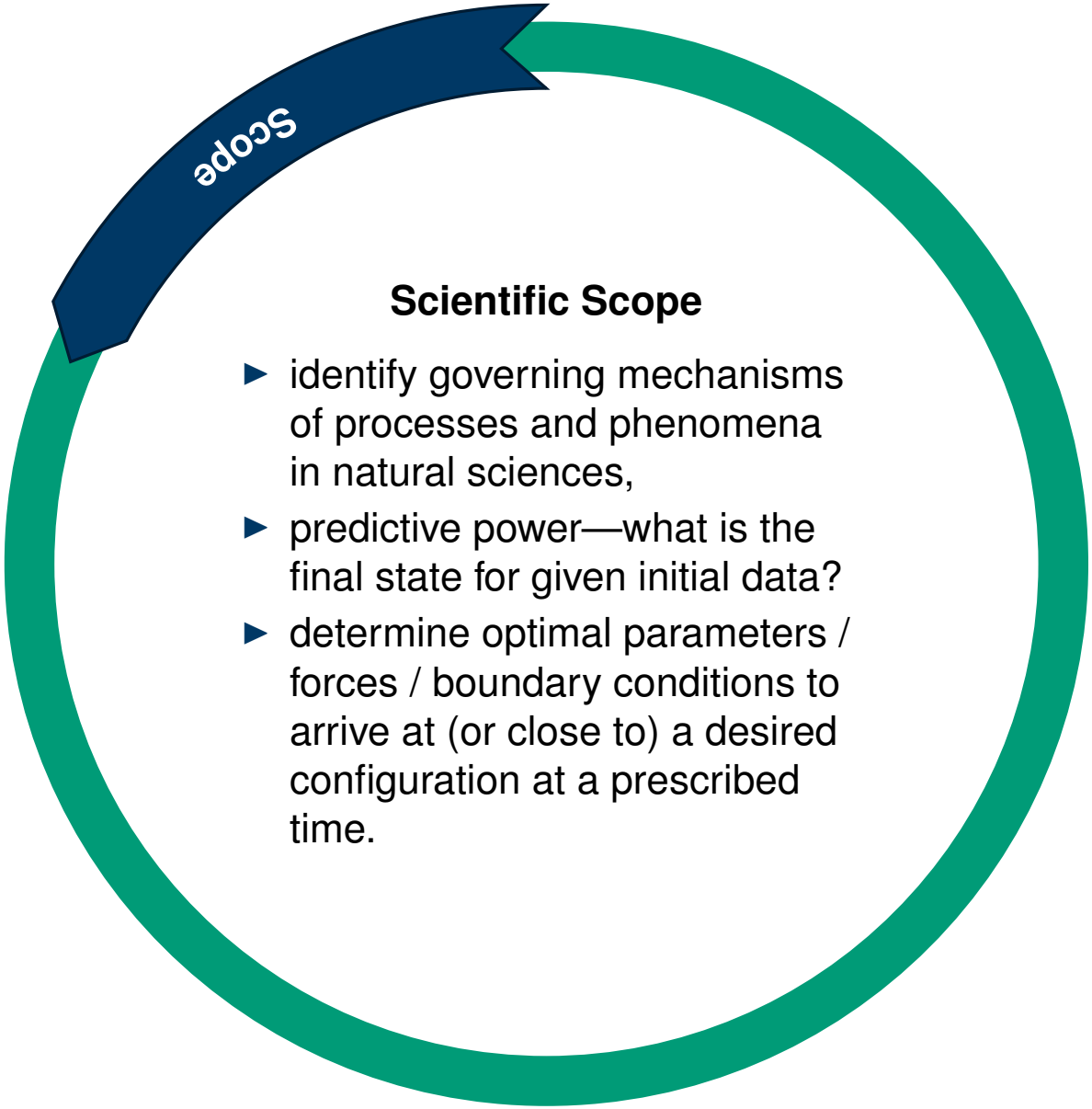
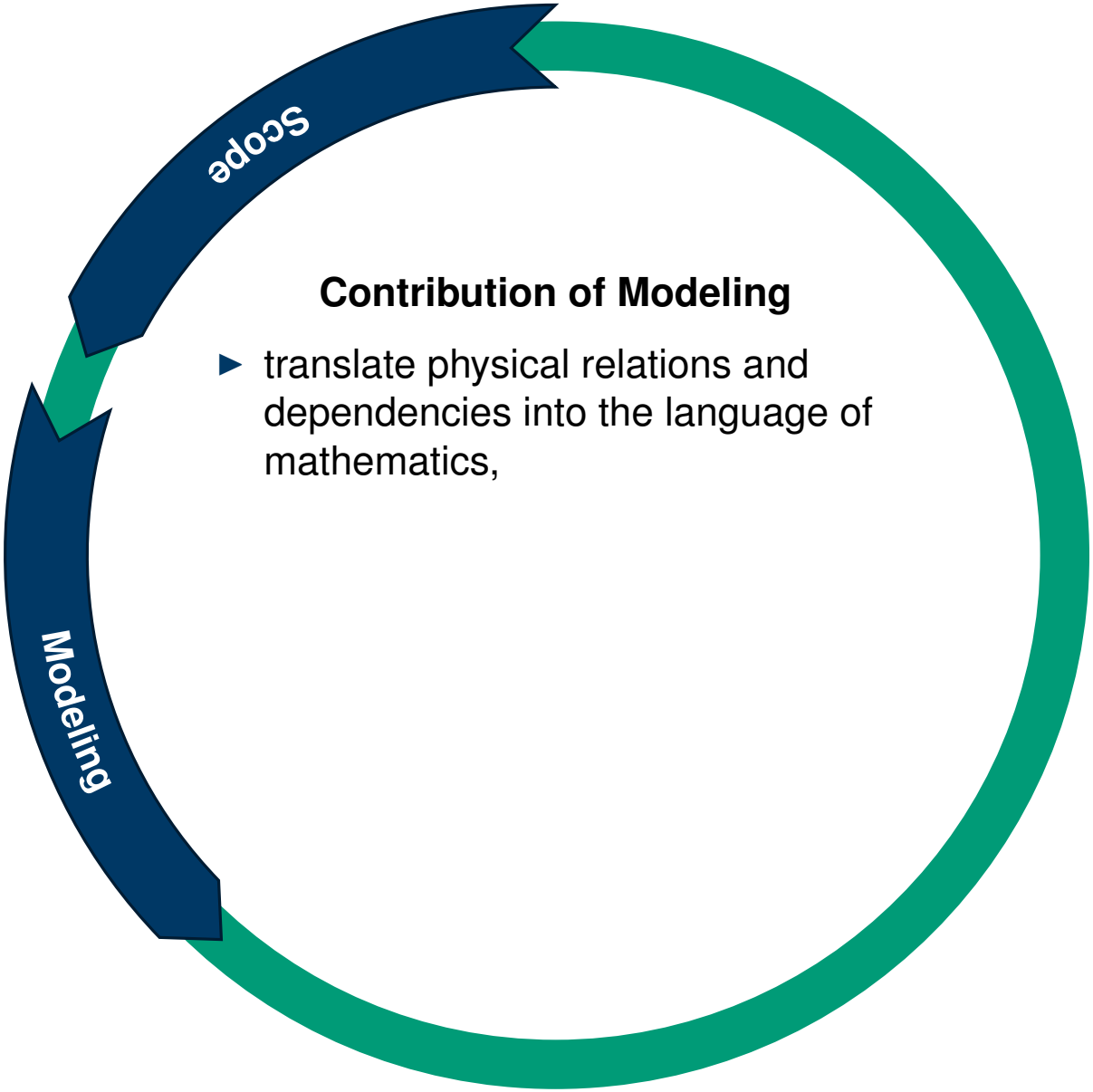
- predictive power—what is the final state for given initial data?



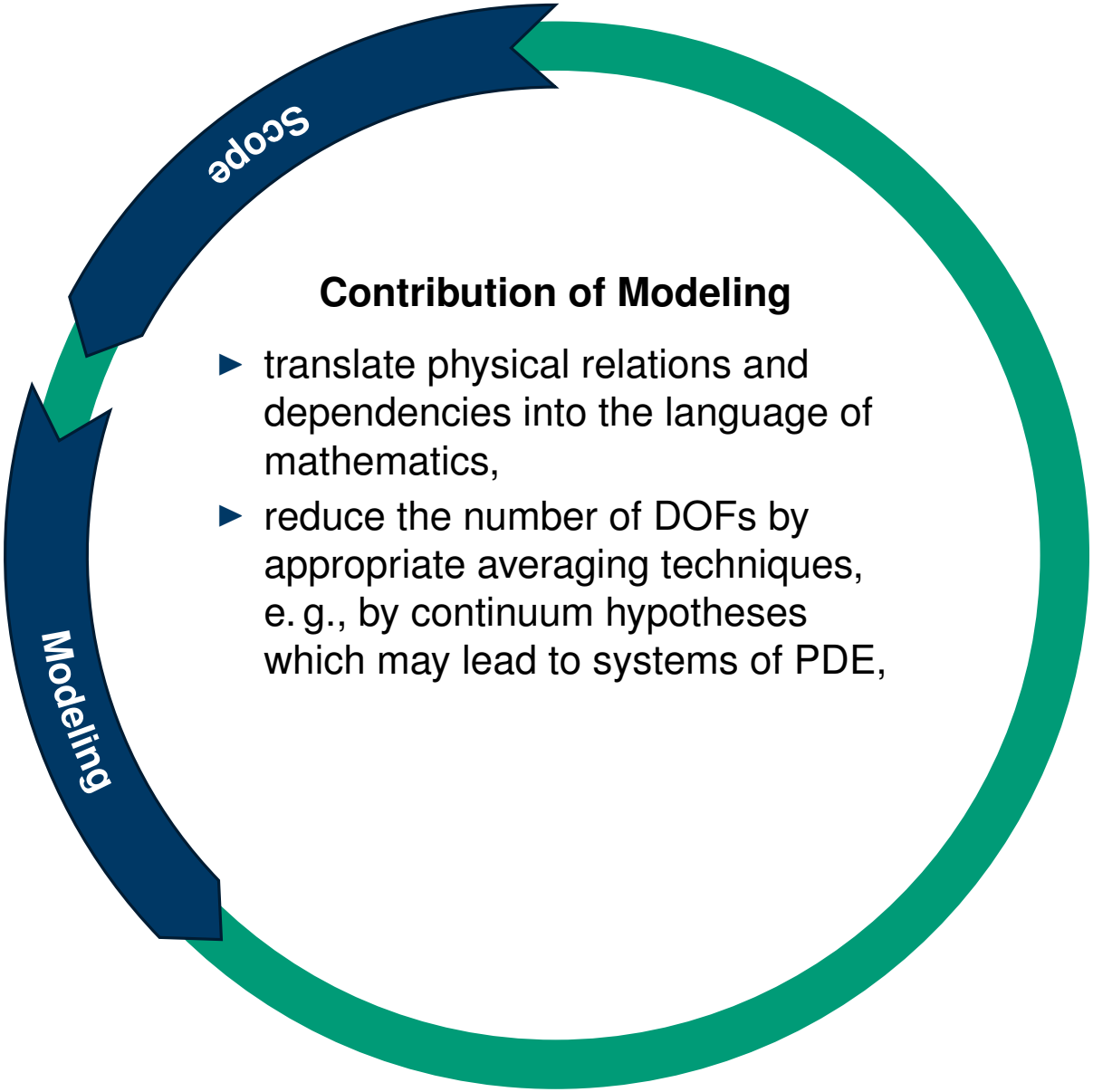
Scientific Scope

- identify governing mechanisms of processes and phenomena in natural sciences,
- predictive power—what is the final state for given initial data?
- determine optimal parameters / forces / boundary conditions to arrive at (or close to) a desired configuration at a prescribed time.



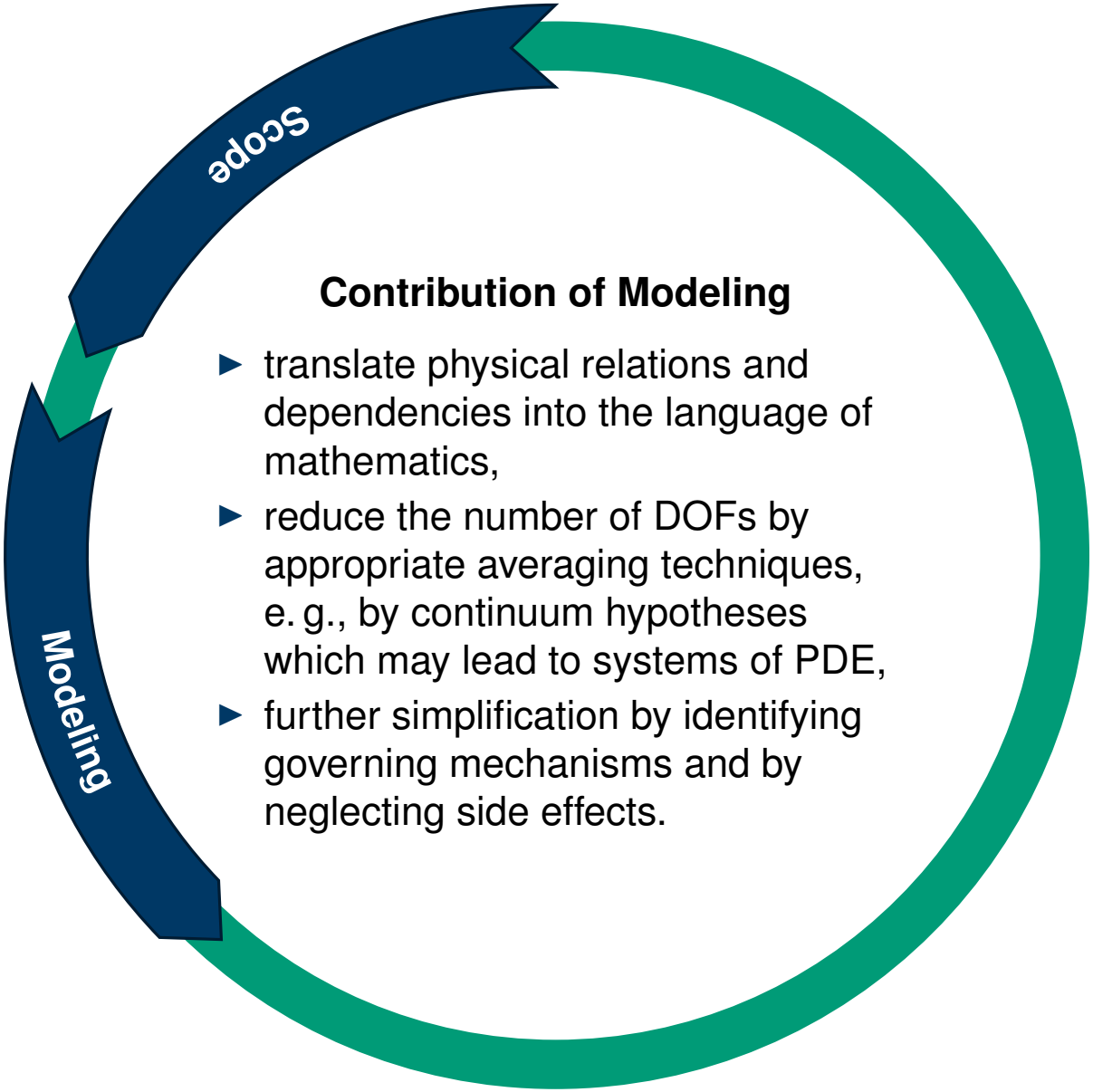
Contribution of Modeling

- translate physical relations and dependencies into the language of mathematics,



Contribution of Modeling

- translate physical relations and dependencies into the language of mathematics,
- reduce the number of DOFs by appropriate averaging techniques, e. g., by continuum hypotheses which may lead to systems of PDE,

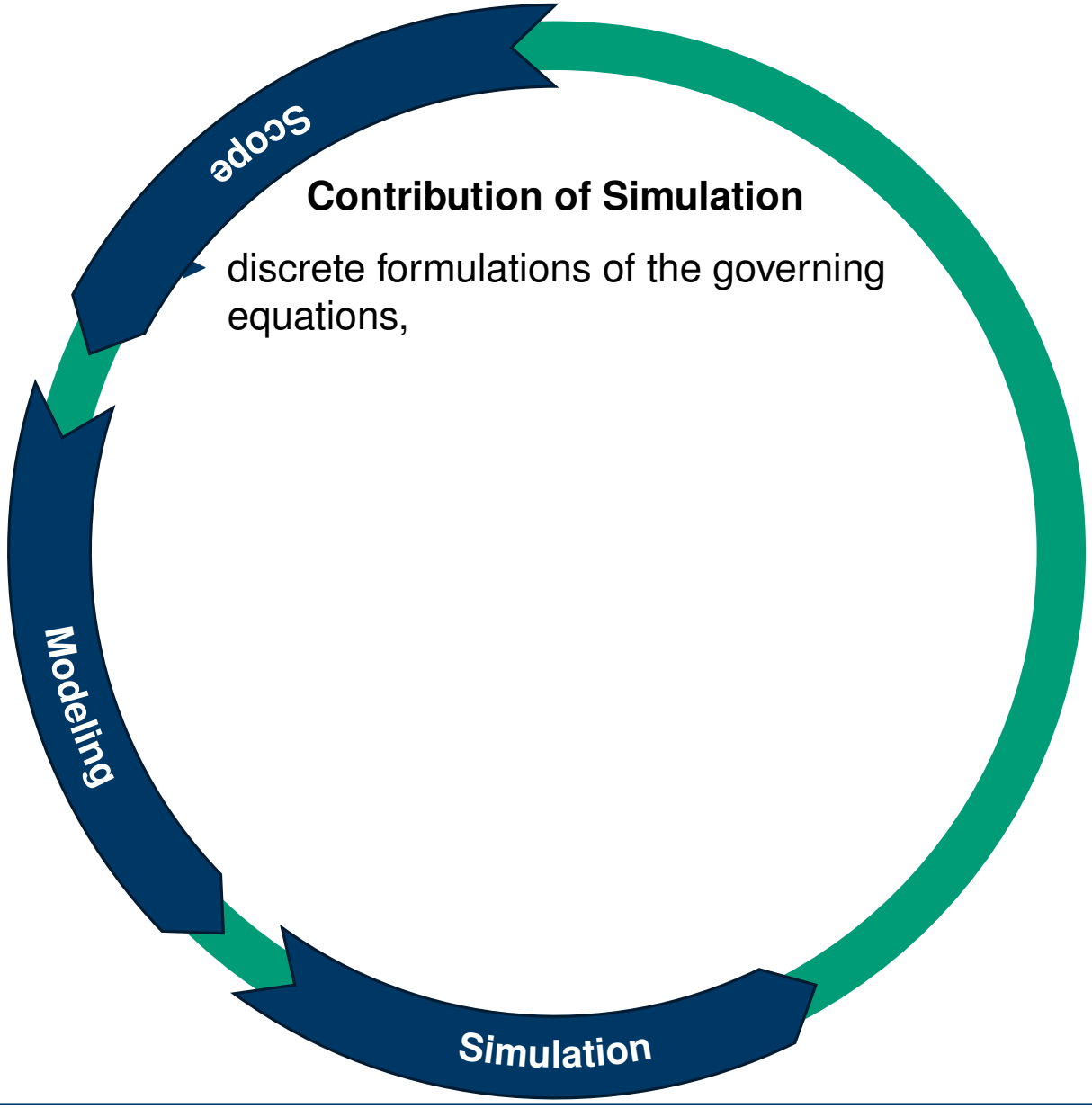


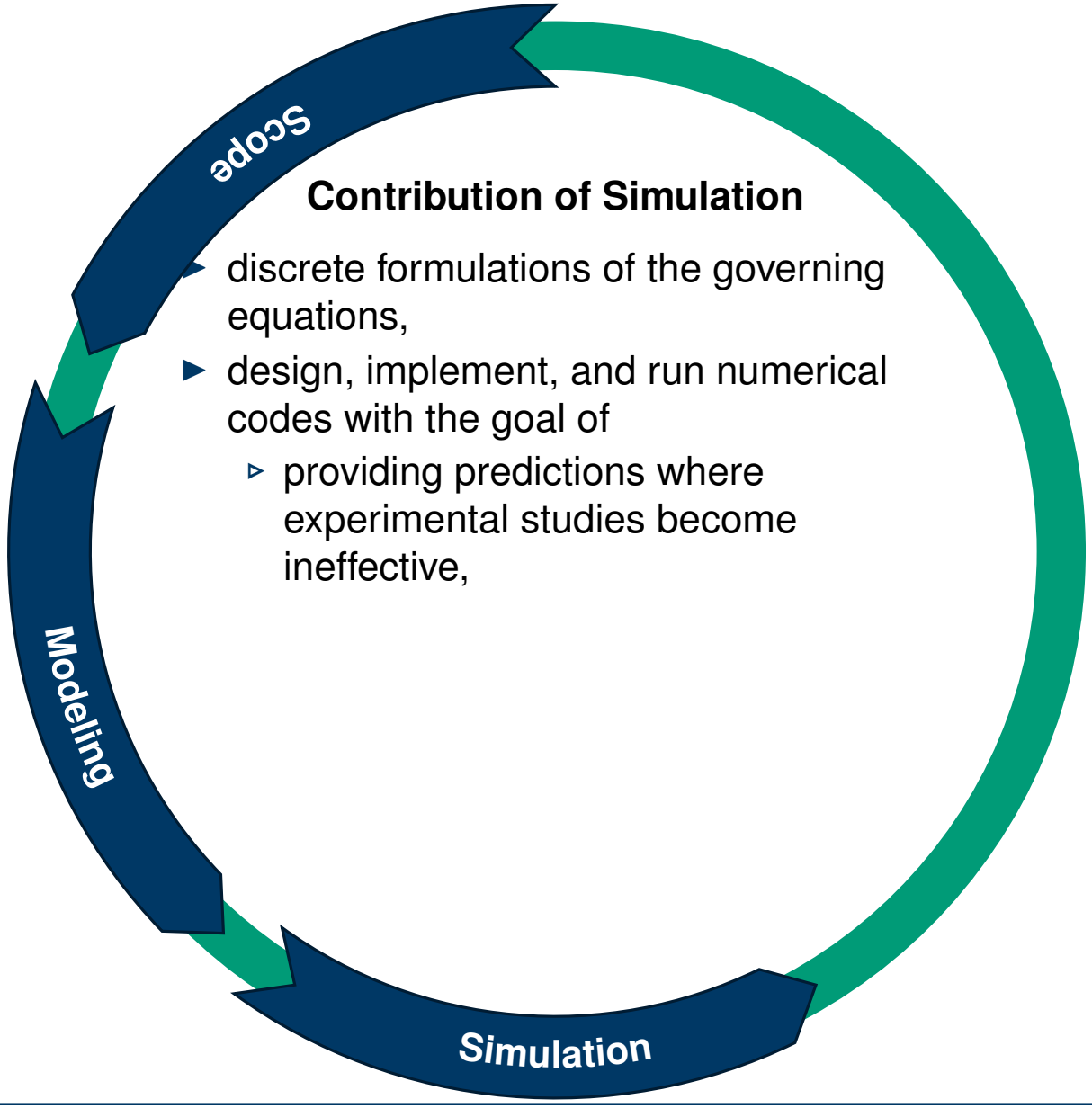
Contribution of Modeling

- translate physical relations and dependencies into the language of mathematics,
- reduce the number of DOFs by appropriate averaging techniques, e. g., by continuum hypotheses which may lead to systems of PDE,
- further simplification by identifying governing mechanisms and by neglecting side effects.

Contribution of Simulation

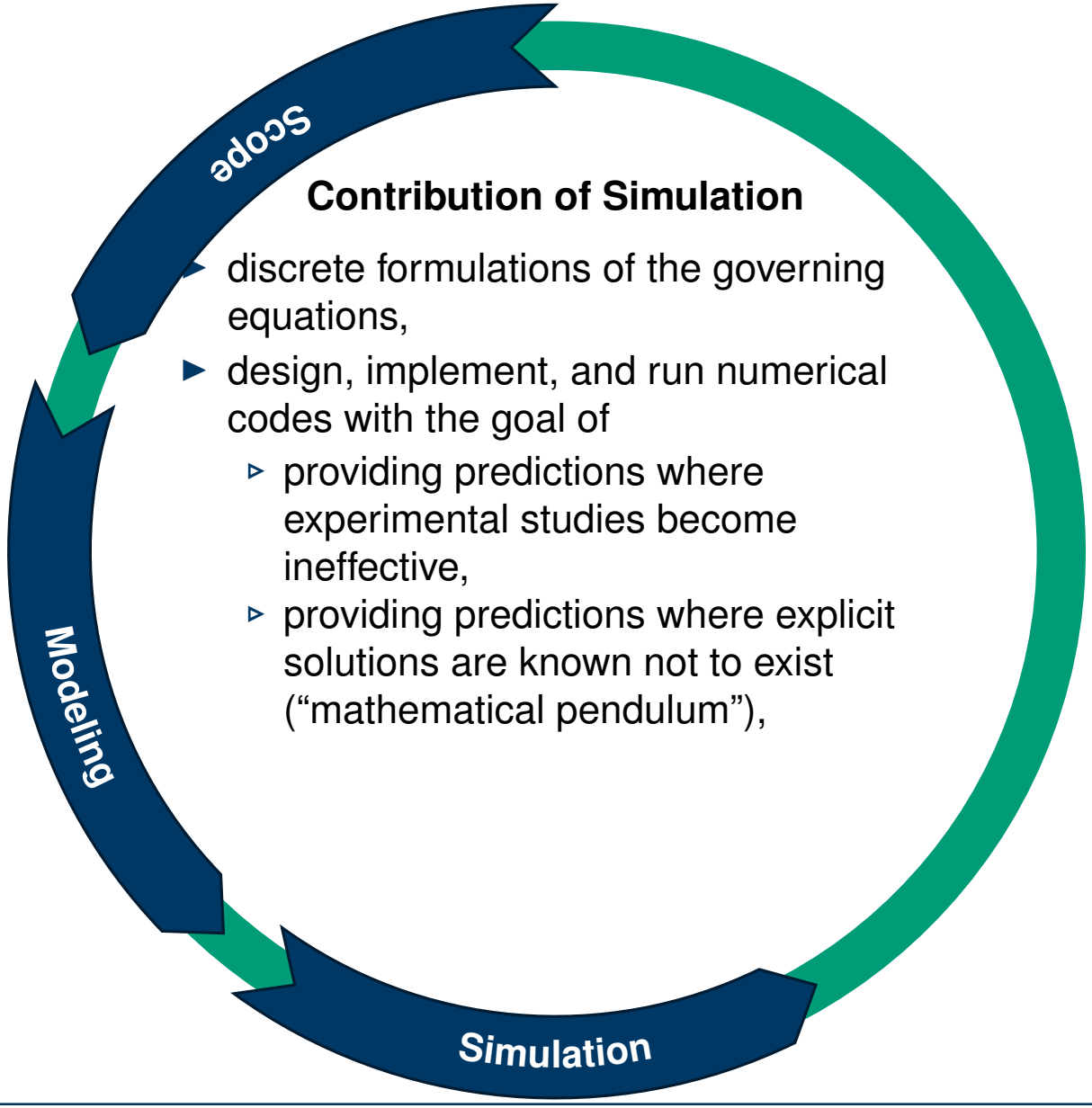
- discrete formulations of the governing equations,





Contribution of Simulation

- discrete formulations of the governing equations,
- design, implement, and run numerical codes with the goal of
  - providing predictions where experimental studies become ineffective,



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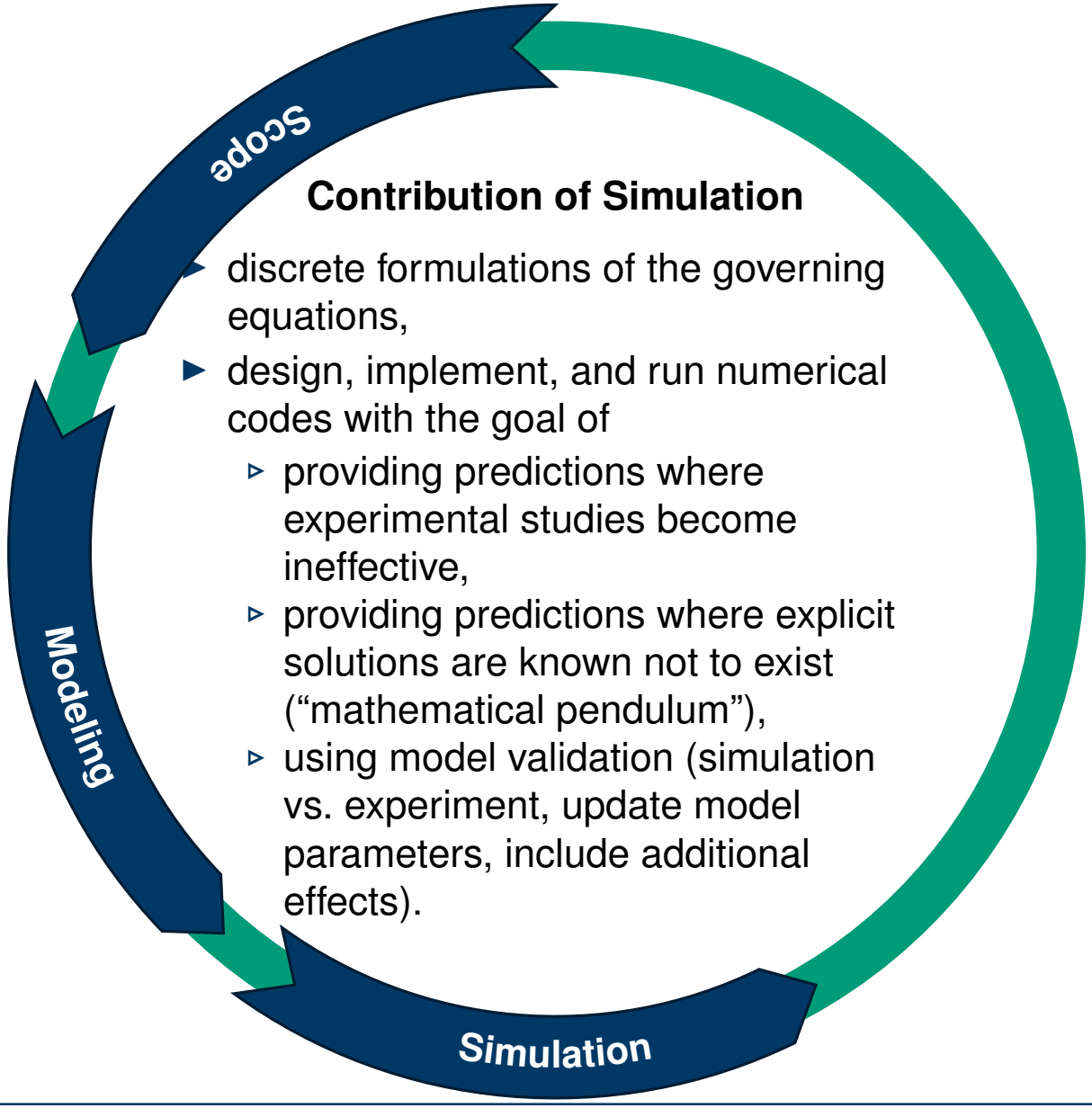

Contribution of Simulation

- discrete formulations of the governing equations,
- design, implement, and run numerical codes with the goal of
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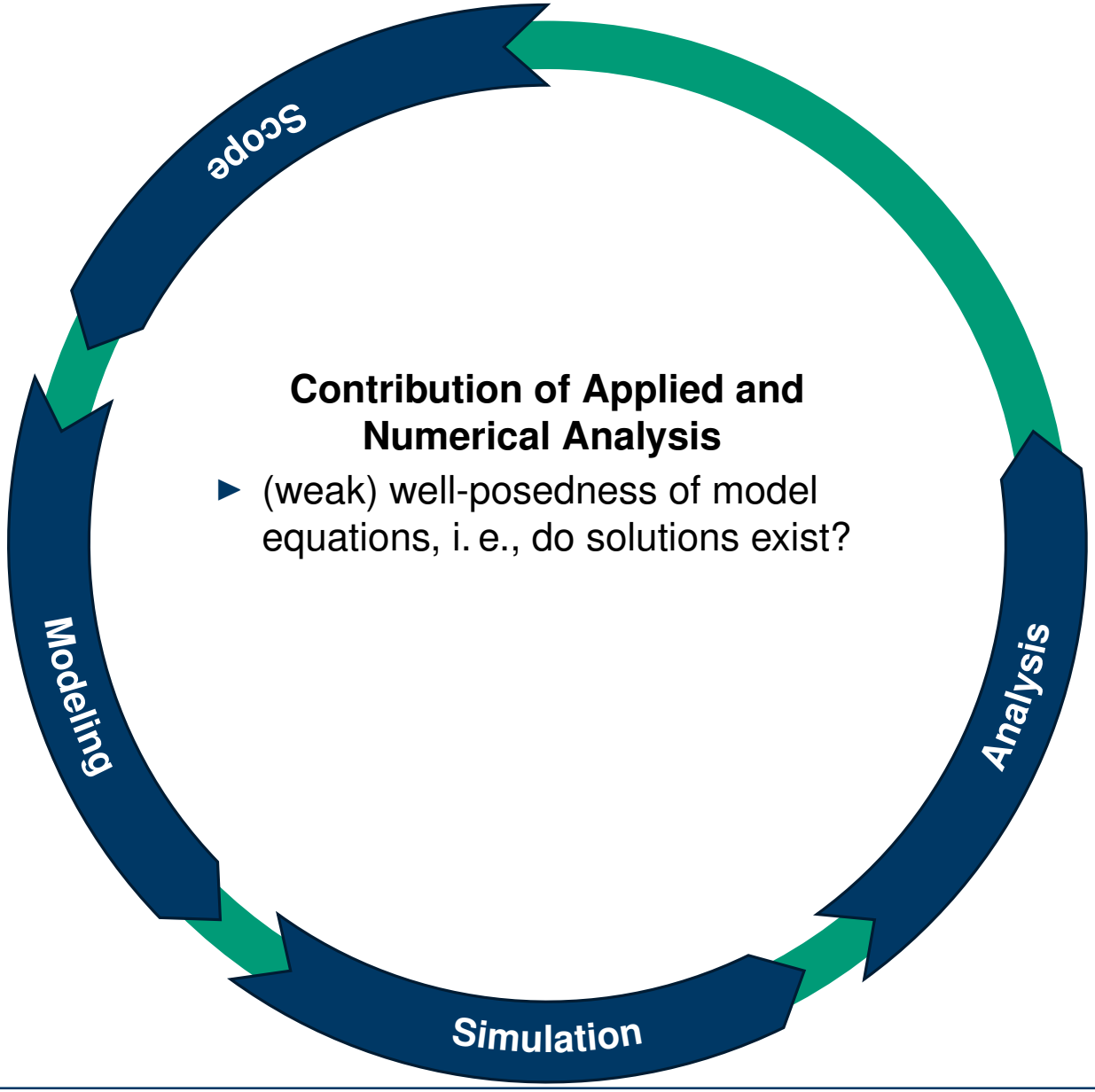
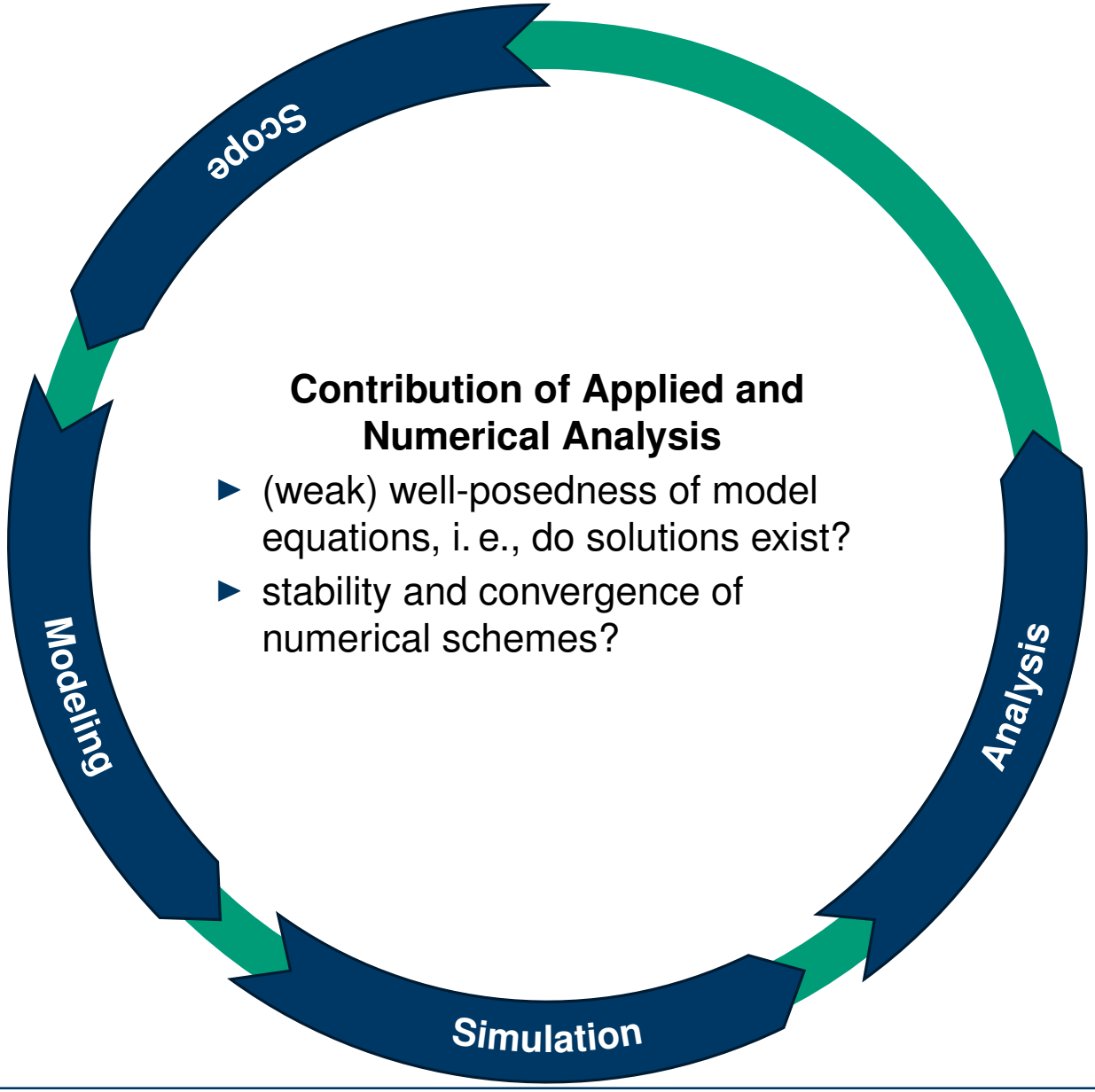
  - providing predictions where explicit solutions are known not to exist (“mathematical pendulum”),
  - using model validation (simulation vs. experiment, update model parameters, include additional effects).



Contribution of Applied and Numerical Analysis

- (weak) well-posedness of model equations, i. e., do solutions exist?



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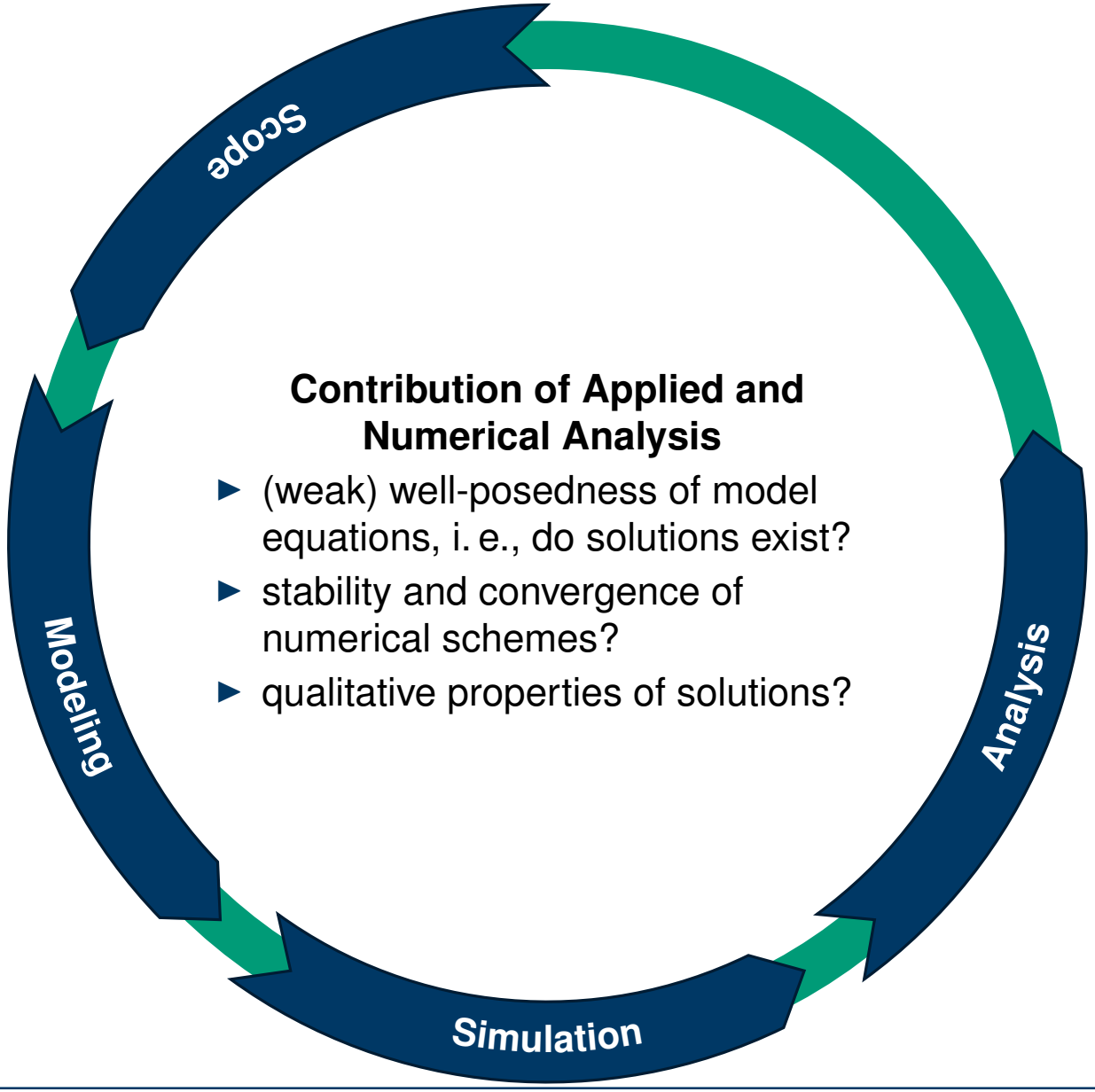
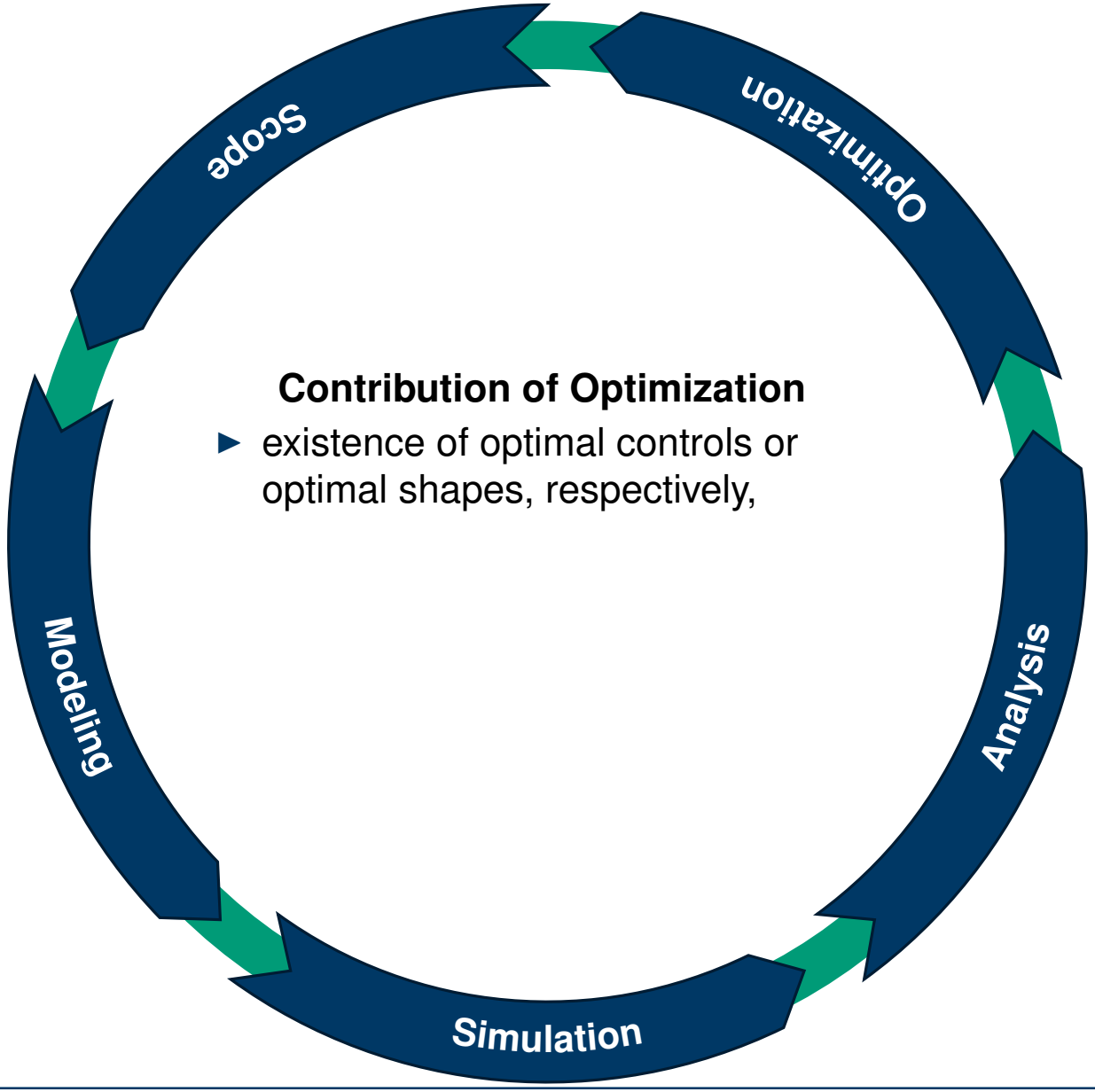
- (weak) well-posedness of model equations, i. e., do solutions exist?
- stability and convergence of numerical schemes?



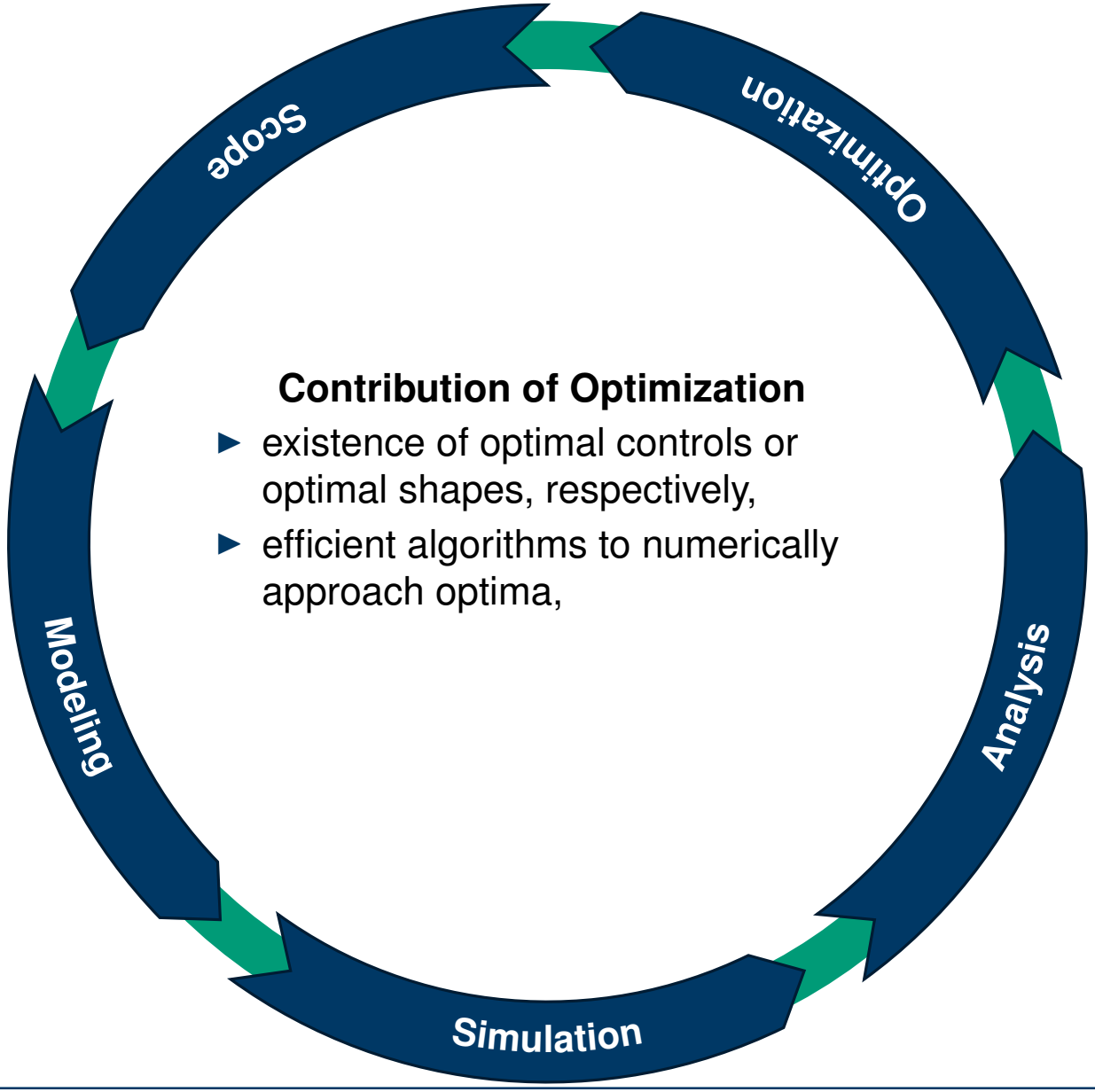
Contribution of Applied and Numerical Analysis

- (weak) well-posedness of model equations, i. e., do solutions exist?
- stability and convergence of numerical schemes?
- qualitative properties of solutions?



Contribution of Optimization

- existence of optimal controls or optimal shapes, respectively,



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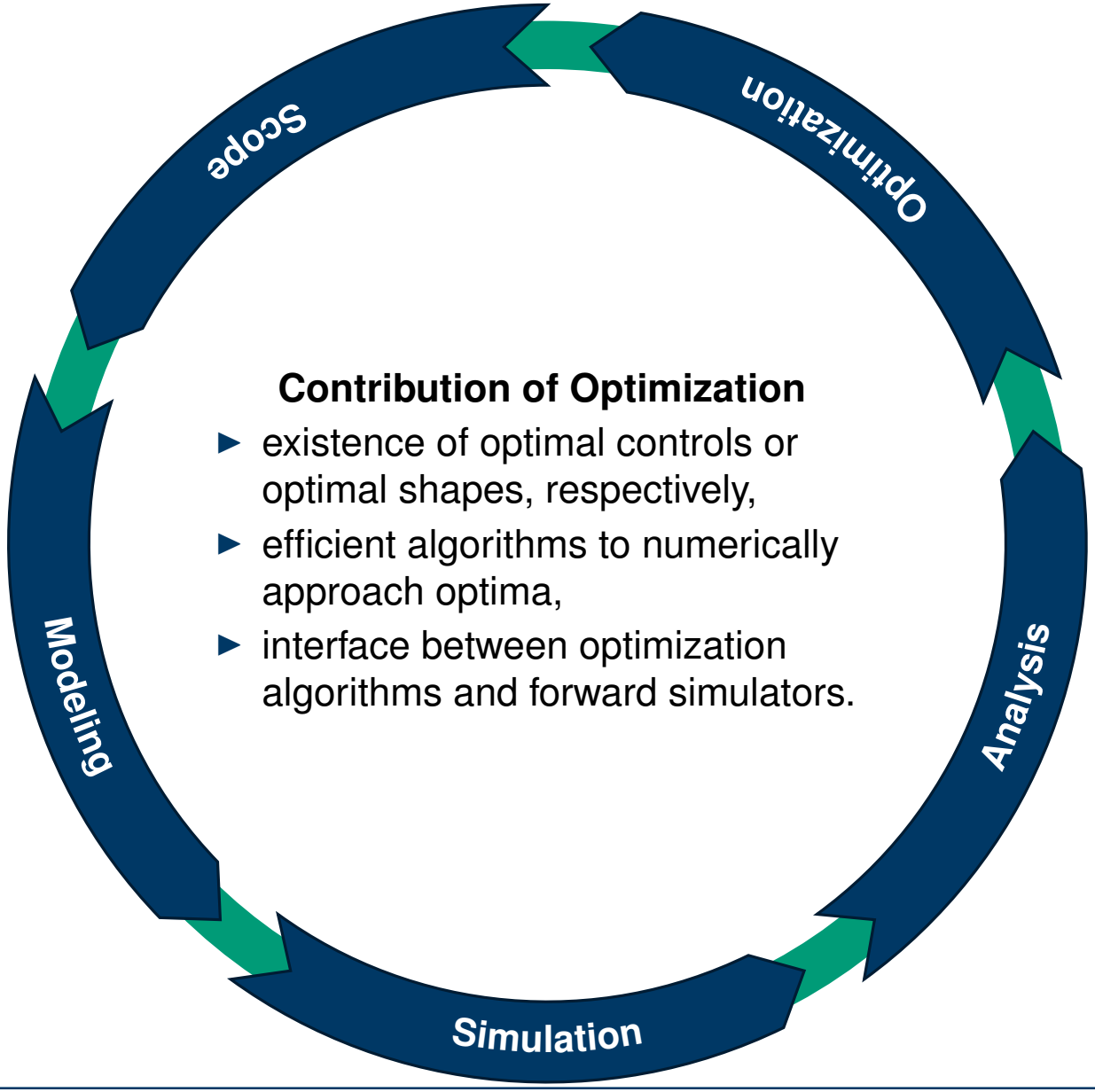

Contribution of Optimization

- existence of optimal controls or optimal shapes, respectively,
- efficient algorithms to numerically approach optima,
- interface between optimization algorithms and forward simulators.

Learning objectives and skills

Students . . .

- work on a problem in engineering or natural sciences as part of a team, but with assigned independent tasks, by constructing a suitable mathematical model and solving it using analytical and numerical methods,

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- develop their communication skills and ability to work as a team through projectwork.