

Starting resources

Use references to support an investigation, not postpone it

The first resource is your topic sheet

The six sheets contain the starting models and essential definitions. The previously distributed course notes supply context: Lecture 2 for compatibility and stiffness; Lecture 4 for discrete updates and action; Lectures 5–6 for variations and generalized coordinates; Lecture 7 for symmetry; the coupled-system and central-force notes for Topics C and D.

You do not need access to the full instructor QABank. The selected topic sheets are self-contained starting assignments. Read only the background relevant to your approved question; the advanced references below are not whole-book reading assignments.

Conventions to keep visible

State versus configuration. Positions or field values alone are configurations. The second-order systems here also require velocities or momenta for a complete instantaneous state. Identify the state before comparing evolution rules.

Steps and velocity. The earlier move-then-turn convention is preserved. In a fixed-step model, s is displacement-like and s/h is velocity-like. Incoming, outgoing, and centered quantities need not be interchangeable. Say where a discrete momentum or velocity is attached.

Spatial mechanics. Keep the factors visible:

$$\mathbf{e} = A\mathbf{u}, \quad V = \frac{1}{2}\mathbf{e}^T C \mathbf{e}, \quad \mathbf{F}_{\text{int}} = -A^T C \mathbf{e}.$$

In a planar framework, A depends on reference geometry as well as connectivity. Positive-definiteness claims require the stated stiffness and support assumptions.

Zero modes. A zero-frequency amplitude satisfies $\ddot{a} = 0$, so $a(t) = a(0) + \dot{a}(0)t$; it need not be static. Normal-mode frequency, stiffness eigenvalue, and degeneracy are different ideas.

Notation. Use L for the Lagrangian, J for the scalar angular momentum in Topic D, and S for action. Use explicit partial derivatives, overdots for time derivatives, and column vectors. Avoid silently importing another source's conflicting notation.

Choose a check that can actually fail

Substitution into an equation tests whether a proposed solution satisfies it. A distinct derivation can expose a hidden assumption. A timestep study tests discretization effects, not the realism of the physical model. Agreement between two programs using the same wrong equation is not an independent physical validation.

For numerical claims, state the dimensionless error or its units, the scale used for normalization, the interval examined, and the refinement criterion. Do not divide by an invariant whose initial value is zero. For interpretive claims, separate what the equations establish from any additional premise.

Selected reading

Starting points, not new prerequisites

General mechanics: Topics C–F, and background for B

David Tong, *Lectures on Classical Dynamics*. The author’s course page provides free lecture notes and individual chapters. Start with the Lagrangian chapter for action, coordinates, symmetry, and small oscillations; use the central-force application for Topic D. Map its notation to the course conventions.

[Author’s lecture-note page](#) [Lagrangian chapter \(HTML\)](#)

The course’s Goldstein, Taylor, and other established references are also appropriate. You are not required to purchase a new text for the project. Read the relevant section rather than treating an entire formalism as a prerequisite.

Discrete mechanics: optional depth for Topics A and B

J. E. Marsden and M. West, *Discrete mechanics and variational integrators*, *Acta Numerica* **10** (2001), 357–514. This is a substantial reference, not assigned cover-to-cover. Use selected passages on discrete Euler–Lagrange equations, discrete momentum/Noether structure, or Verlet-type methods after your baseline calculation works. The project does not require its full geometric machinery.

[Caltech author repository](#) [Publication record / DOI](#)

Foundations: Topic F

Jeremy Butterfield, *Some Aspects of Modality in Analytical Mechanics*, arXiv preprint physics/0210081. Focus on the discussion of variational principles and possible paths that differ from the actual dynamics. Distinguish the author’s argument from the elementary oscillator examples you establish yourself. You do not need to master the entire Hamilton–Jacobi discussion to start.

[Author’s preprint record](#) [PhilSci-Archive record](#)

This is a starting source, not a prescribed conclusion. Add a suitable source for an opposing position when your particular interpretive claim requires it. Do not cite a paper you have not inspected, and do not rely on an AI-generated description as a substitute for reading the relevant passage.

How to use software documentation

Consult the documentation installed with your MATLAB or Python environment for the actual ODE, eigenvalue, quadrature, and interpolation routines used. Report method, tolerances, and software version when they affect the result. A solver’s success message does not establish that the chosen model or diagnostic is correct.

External readings are linked, not redistributed in this ZIP. Required project definitions and all submission templates are included locally.

[Package index](#) [Topic chooser](#)