Dynamics

Engineering Mechanics: Dynamics

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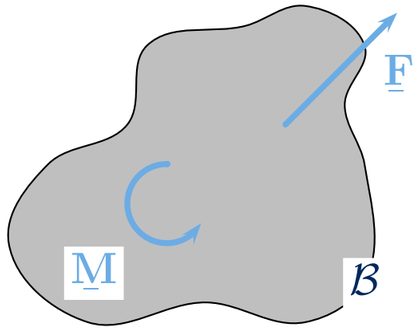
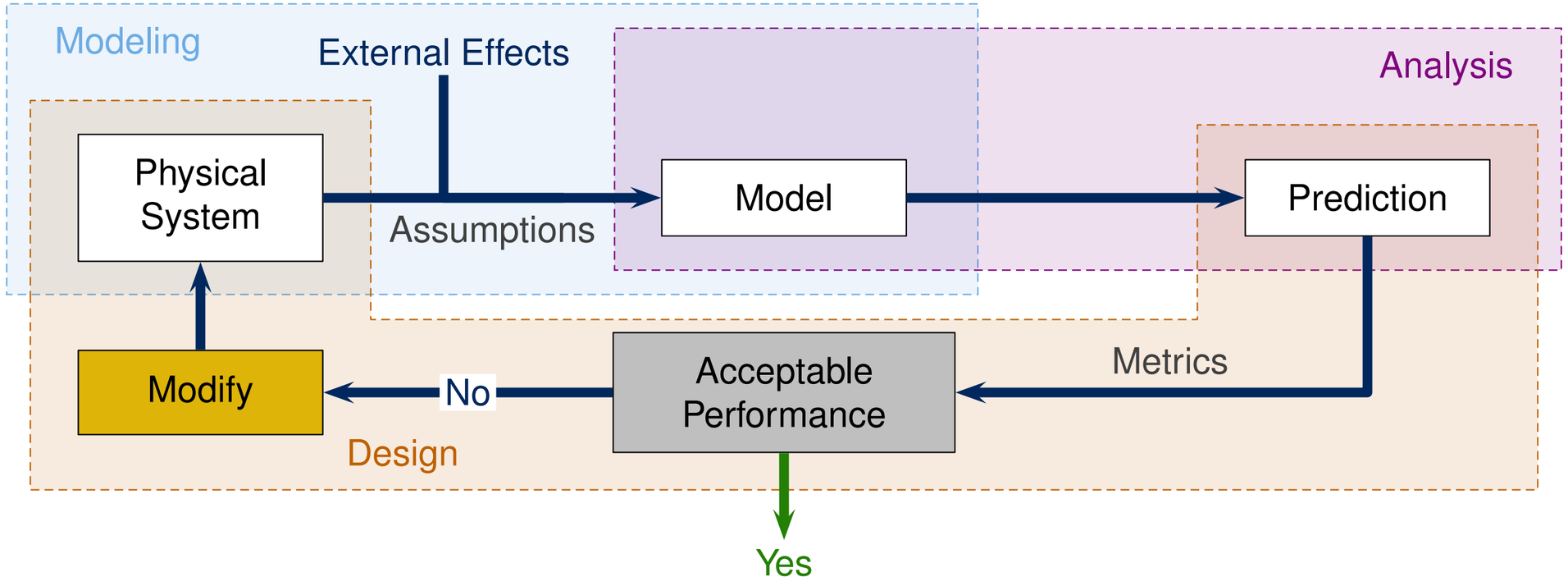
Develop models to *predict* the response of mechanical systems to external effects.



- Relate the external forces ($\underline{\mathbf{F}}$) and moments ($\underline{\mathbf{M}}$) acting on an object ($\mathcal{B}$) to the motion of that object

Engineering Design

- Allows for the *design* of mechanical systems under dynamic conditions



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Newton's Laws of Motion (Sir Issac Newton, 1642–1727; *Principia* (1687))

I. The motion of a particle is uniform unless a force is applied to the particle.

Defines an inertial frame of reference

II. The time rate of change of linear momentum is equal to the net force acting on the particle.

$$\sum \underline{\mathbf{F}} = \frac{d}{dt}\left(m\,\underline{\mathbf{v}}\right) \qquad \text{Linear momentum balance}$$

III. For every action there is an equal and opposite reaction.

Describes the interaction between particles

These are defined for a particle—an object with finite mass but infinitesimal size (also known as a point mass)

For constant mass

$$\overbrace{\underbrace{\sum \underline{\mathbf{F}}}_{\text{Kinetics}} = \underbrace{m\,\underline{\mathbf{a}}}_{\text{Kinematics}}}^{\text{Dynamics}}$$

The acceleration is with respect to an inertial frame of reference

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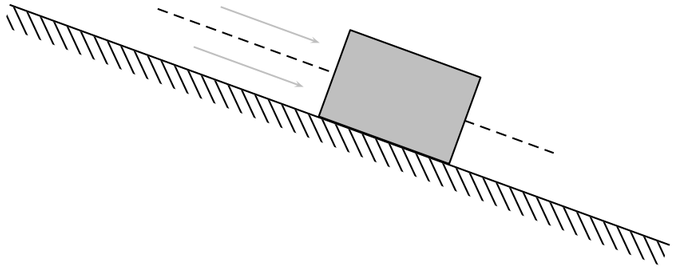
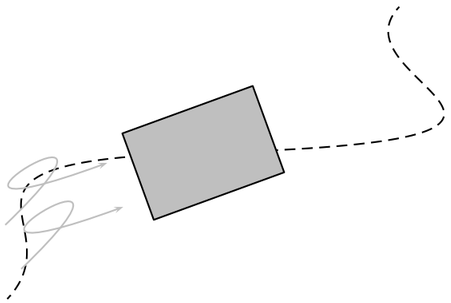
Dynamics: Application of the laws of mechanics to develop equations of motion that describe the response of a system to external effects

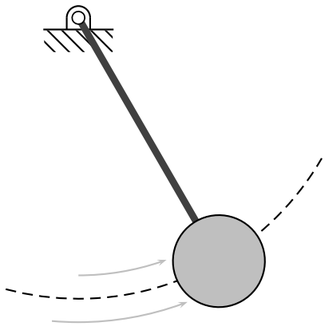
What motion occurs?

Kinematics: Consideration of the allowable motion of an object, consistent with the constraints that act on that object, without regard to the forces that produce motion or the motion that actually occurs

What motion could occur?







Kinetics: Description of the forces that are applied to a mechanical system

What forces cause motion?

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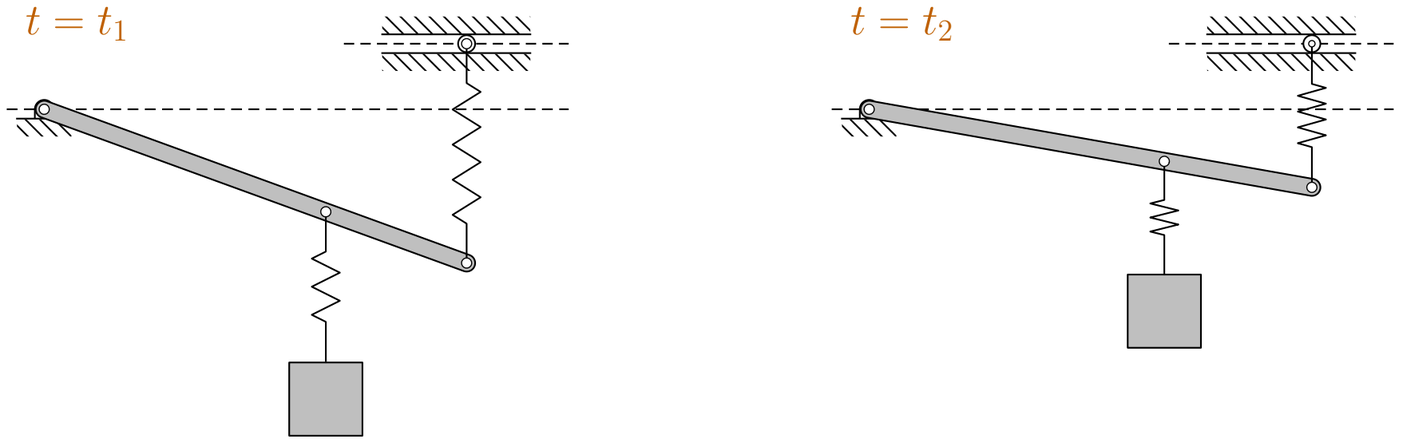
Kinematics

Describe the position, velocity, and acceleration of an object in terms of coordinates that specify the configuration of the system.

System: a collection of objects of interest

Configuration: physical space occupied by a system at an instant in time



Coordinates: measurable quantities (e.g. distance, angle) that specify the configuration of the system

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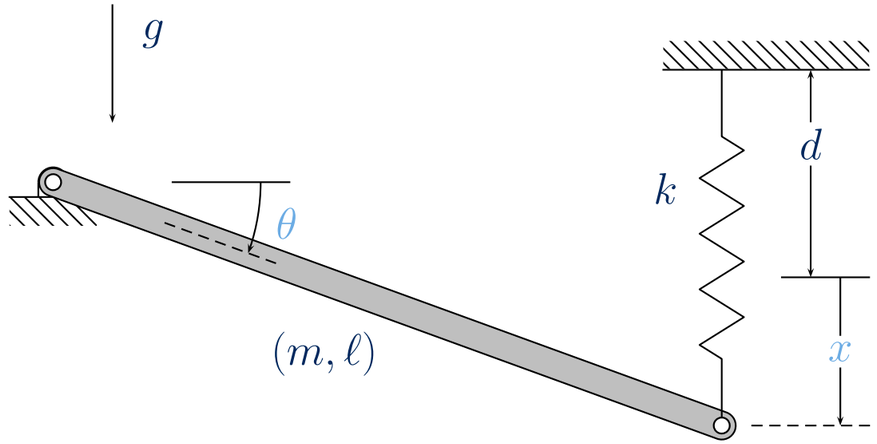
Describe the position, velocity, and acceleration of an object in terms of coordinates that specify the configuration of the system.

We distinguish between *parameters* and *coordinates*

- Parameters can be measured *independent of the configuration*.
- Coordinates *depend on the configuration*.

Parameters: Measurable
Constant (typically)
Specify properties of the objects
m, ℓ, k, d, and g are parameters

Coordinates: Measurable
Time-dependent
Specify the configuration of the system
$\theta(t)$ and $x(t)$ are coordinates



Degree-of-freedom (dof): Minimum number of coordinates needed to uniquely specify the configuration of the system

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