

# Dynamics

## Engineering Mechanics: Dynamics

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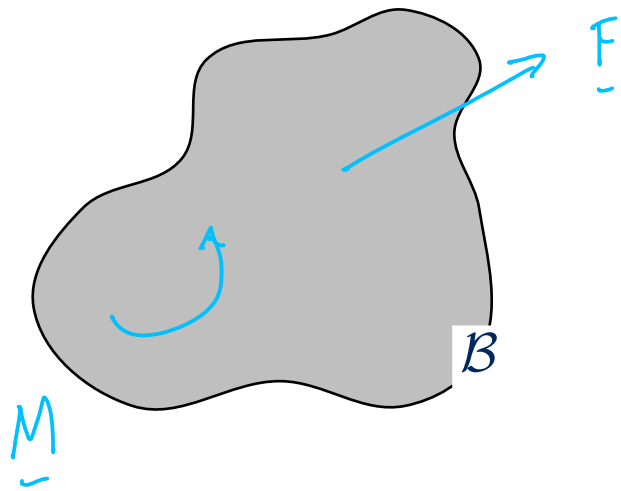
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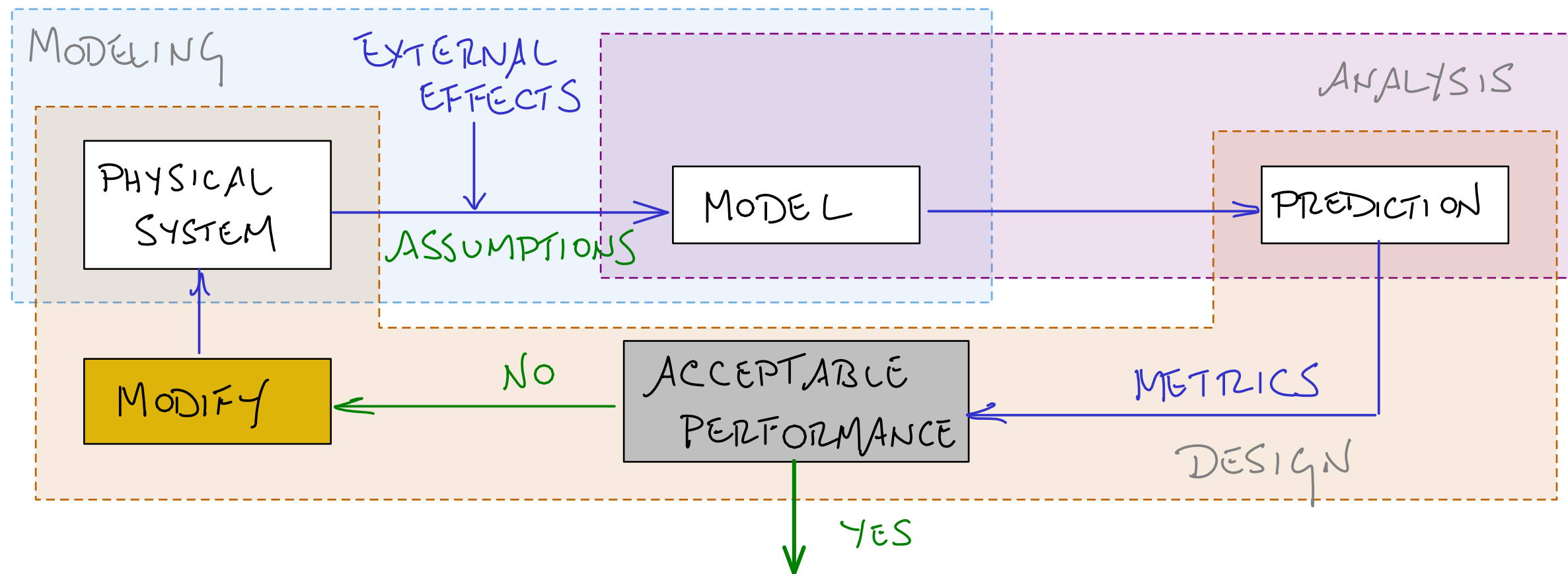
Develop models to *predict* the response of mechanical systems to external effects.



- RELATE EXTERNAL FORCES ( $\underline{F}$ ) + MOMENTS ( $\underline{M}$ ) ACTING ON B TO THE MOTION OF THAT OBJECT

### Engineering Design

- ALLOWS FOR THE DESIGN OF MECHANICAL SYSTEMS



# 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.

$$\sum \underline{F} = \frac{d}{dt} (m \underline{v}) \quad \text{LINEAR MOMENTUM BALANCE}$$

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  
DYNAMICS

$$\sum \underline{F} = m \underline{a}$$

KINETICS

KINEMATICS

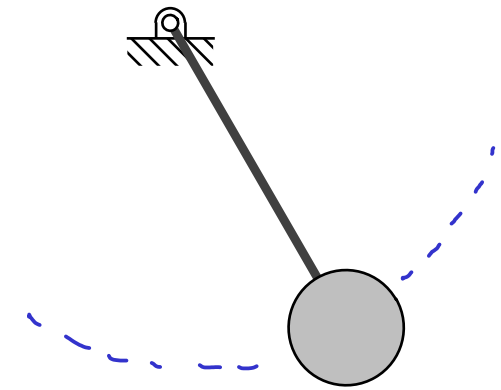
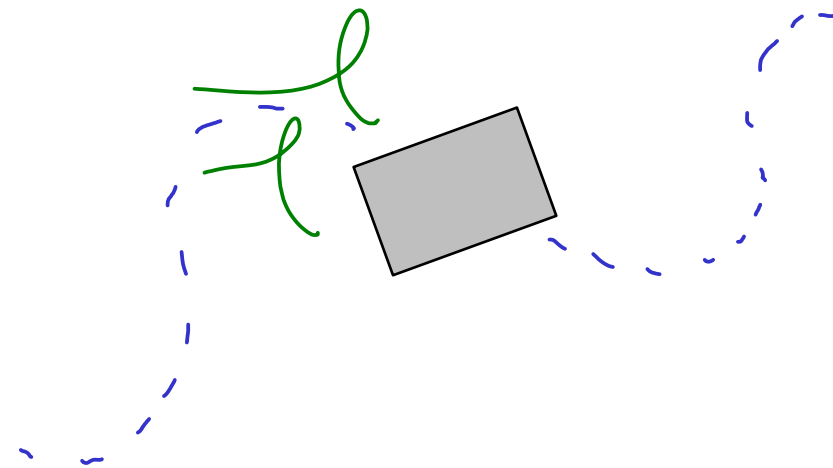
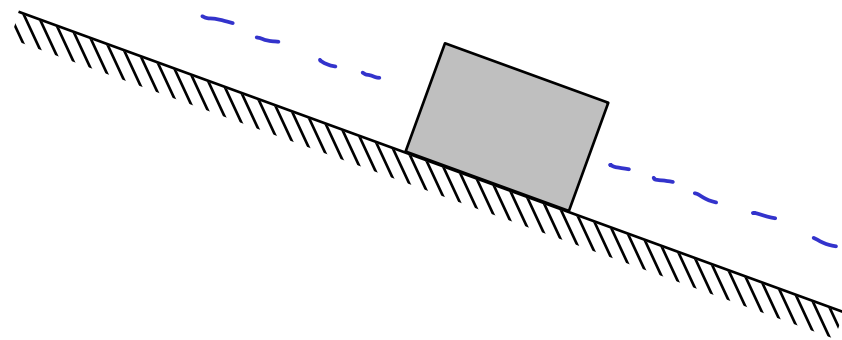
ACCELERATION WITH RESPECT  
TO INERTIAL SPACE

**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

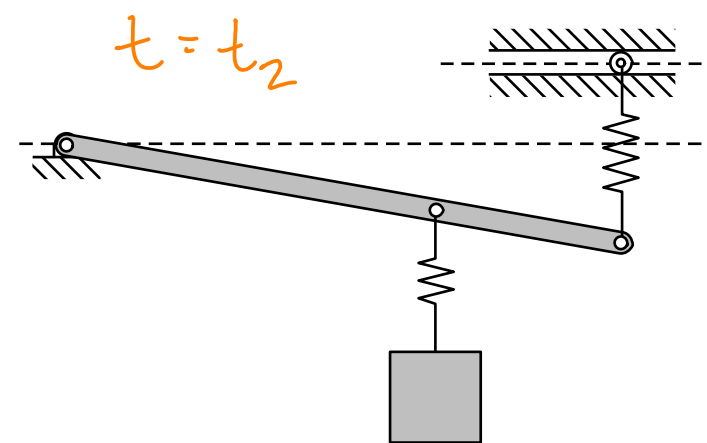
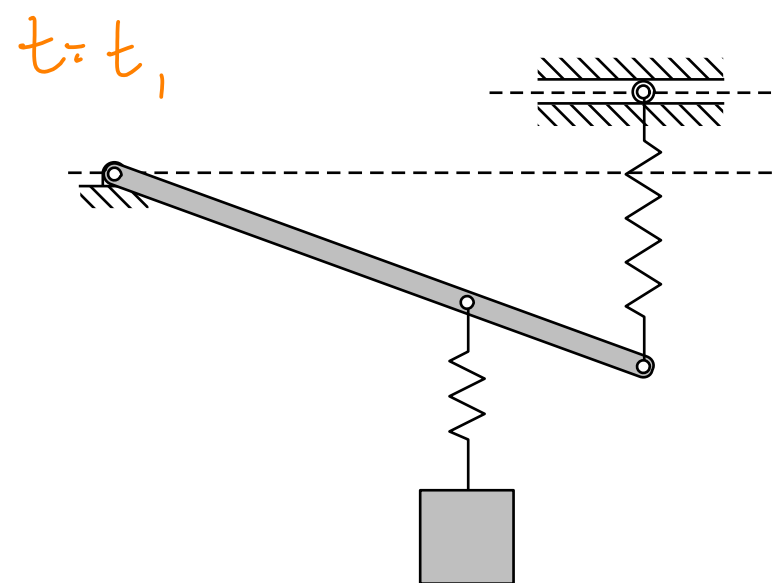
WHAT FORCES CAUSE MOTION?

# 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

CONFIGURATION - PHYSICAL SPACE OCCUPIED BY THE SYSTEM



COORDINATES - MEASURABLE QUANTITIES (e.g. DISTANCE, ANGLE) THAT SPECIFY THE CONFIGURATION

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

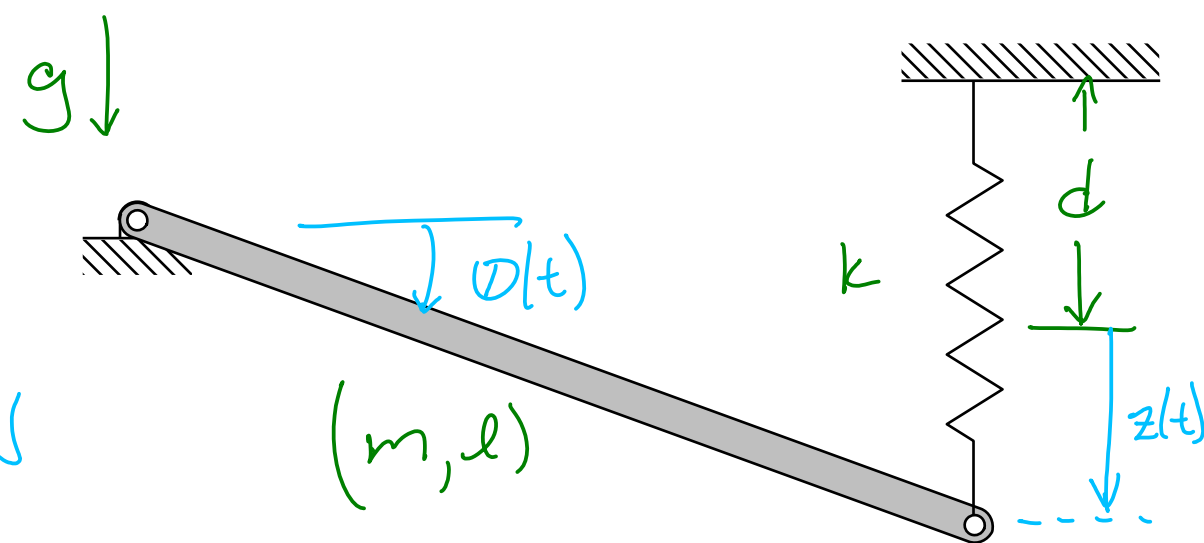
DISTINGUISH BETWEEN **COORDINATES** & **PARAMETERS**

**PARAMETERS** ARE INDEPENDENT OF CONFIGURATION

**COORDINATES** DEPEND ON THE CONFIGURATION

**PARAMETERS** - MEASURABLE  
CONSTANT

**COORDINATES** - MEASURABLE  
SPECIFY THE CONFIGURATION  
TIME-DEPENDENT



DEGREE-OF-FREEDOM (dof): MINIMUM NUMBER OF COORDINATES  
NEEDED TO SPECIFY THE CONFIGURATION