Week 6, 5 & 12 March

Mechanics in Energy Resources Engineering - Chapter 4 Shear Forces and Bending Moments

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1st exam

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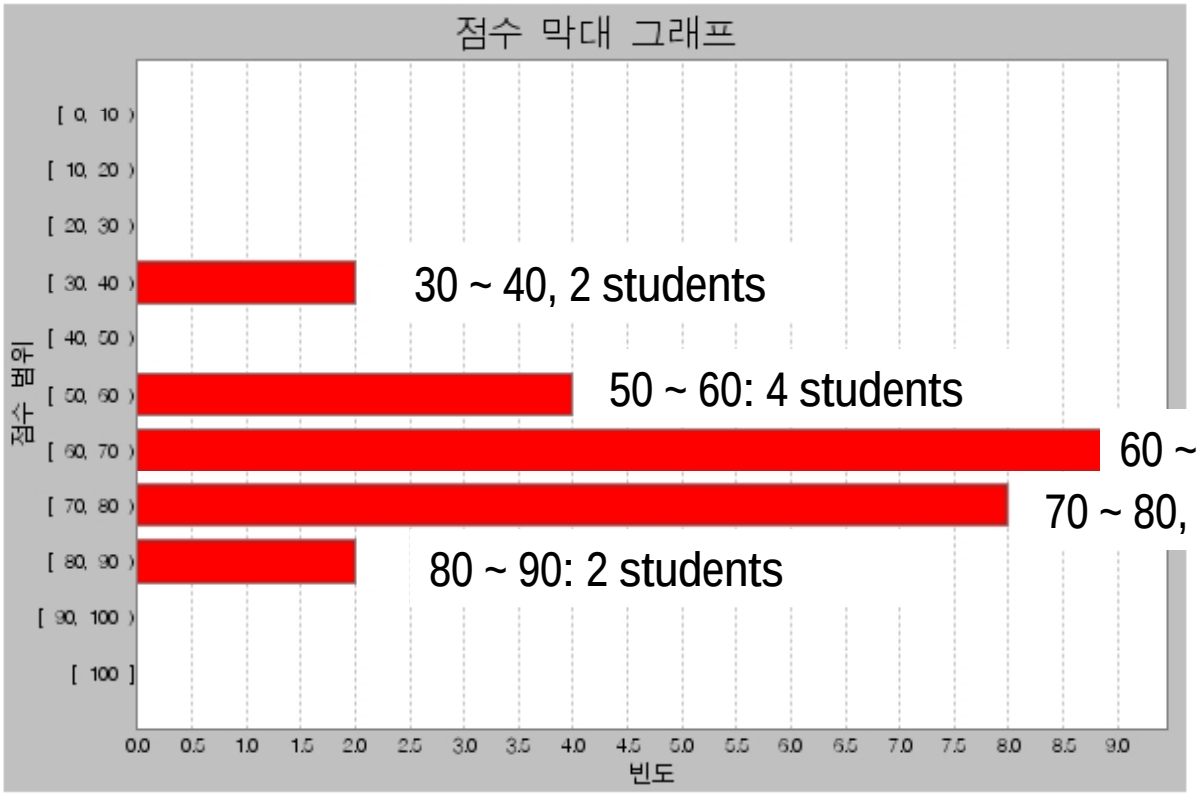
- Mean: 65.3, standard deviation: 12.9
- Max: 86.0, Min: 30.0



1st Exam

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- In general, you demonstrated your understanding to a reasonable extent and you are in good positions to study further.
- Try to thoroughly understand the home assignments. I encourage discussion with your peers.
- This time only, partial point was around 10% - 70%. However, it will be minimized next time. Max partial point will be 30%.
- Level of difficulty will be similar in the 2nd and 3rd exam.
- 2nd exam: Ch. 4, 5 & 12
- 3rd exam: entire chapters.

Review

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- Introduction
- Torsional Deformations of a circular bar (원형봉의 비틀림 변형)
- Circular bars of linearly elastic materials (선형탄성 원형봉)
- Nonuniform torsion (불균질 비틀림)
- Stresses and Strains in Pure Shear (순수전단에서의 응력과 변형율)
- Relationship Between Moduli of Elasticity E and G (탄성계수 E와 G의 관계)
- Statically Indeterminate Torsional Members (부정정 비틀림 부재)
- Strain Energy in Torsion and Pure Shear (비틀림과 순수전단에서의 변형에너지)

Change of schedule

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- 5 April (Ch.4)
- 12 April (Ch.4)
- 19 April (Ch.5), hw#5 due
- 26 April (Review),

7 April (Ch.12) by Jae-Won Lee

14 April (Ch.5), hw#4 due

21 April (Ch.5)

28 April (2nd Exam), hw#6 due

Preview

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- Introduction
- Types of Beams, Loads, and Reactions
- Shear Forces and Bending Moments
- Relationships Between Loads, Shear Forces and Bending Moments
- Shear-Force and Bending-Moment Diagrams

Introduction

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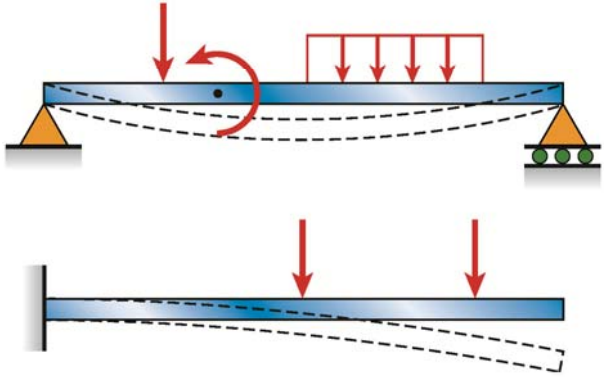
- Structural members
  - Axially loaded bar (봉): forces along the axis
  - A bar in torsion: torques along the axis (moment vectors)
  - Beam (보): lateral loads
- *Planar structure* lie in a single plane
  - Loads and deflections occurs in the *plane of bending*



Types of Beams, Loads, and Reactions
beams

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- Assumptions
  - Loads act in the plane of the figure: force vectors in the plane of figure & bending moments have their moments vectors perpendicular to the plane of the figure
  - Beam is symmetric about that plane → deflect only in the plane of bending

Types of Beams, Loads, and Reactions
Types of Beams

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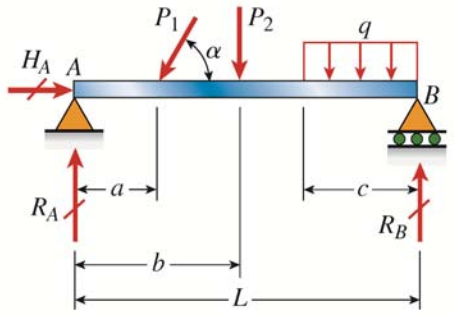
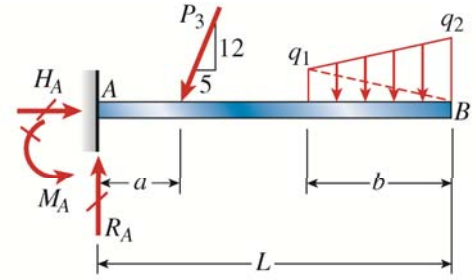
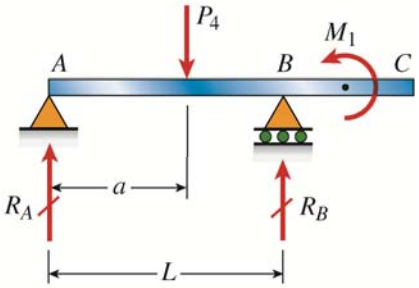
- Simple beam (단순보)



- Cantilever beam (캔틸레버 보)



- Beam with an overhang (돌출보)



Types of Beams, Loads, and Reactions
Types of supports

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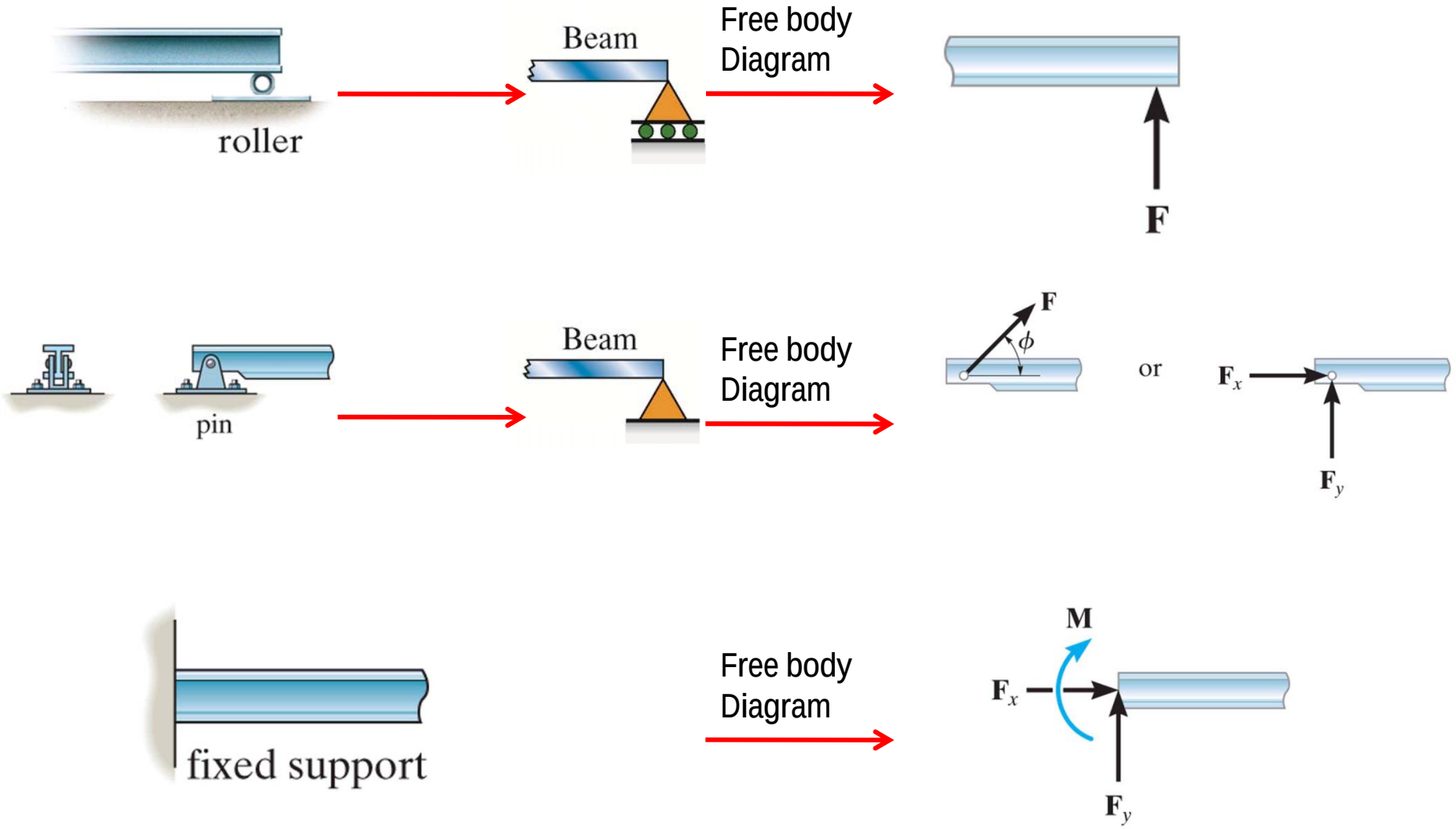

Types of Beams, Loads, and Reactions
Actual Examples

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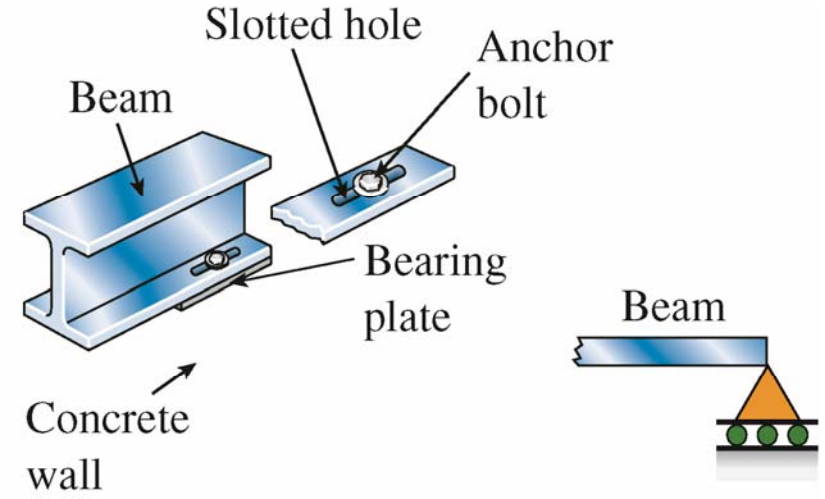

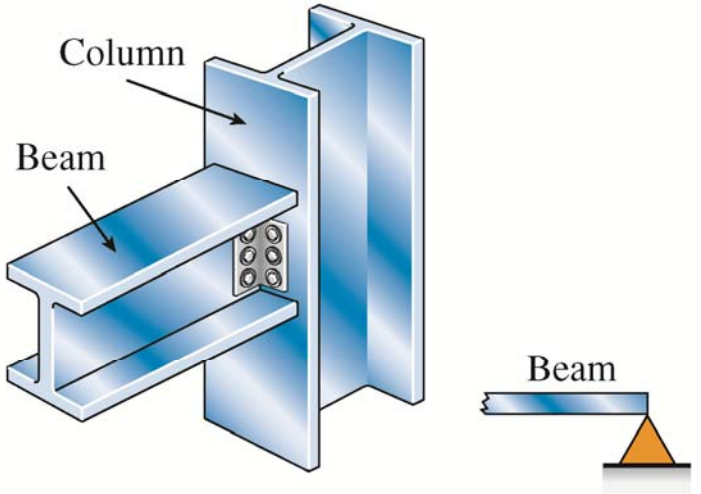

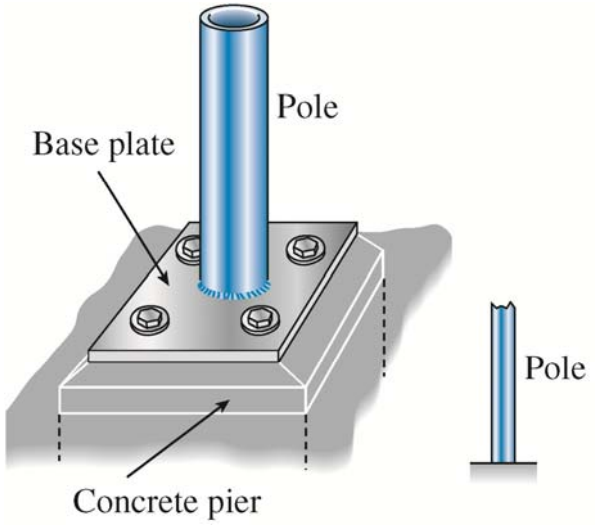

Types of Beams, Loads, and Reactions
Loads

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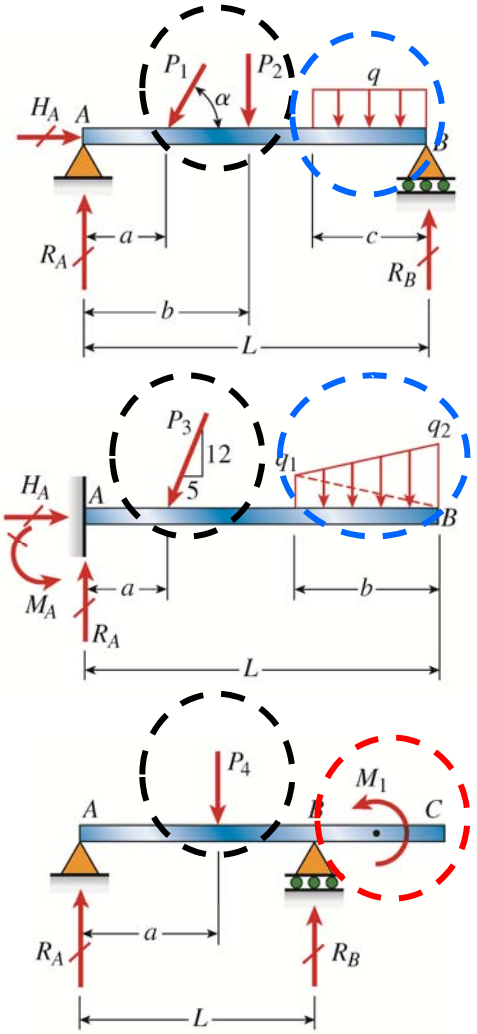
- Concentrated load
  - applied over a very small area
- Distributed load
  - Spread along the axis of a beam
  - Measured by their intensity (Force/unit distance)
  - Uniformly distributed & linearly varying load
- Couple
  - The couple of moment M_1 acting on the overhang



Types of Beams, Loads, and Reactions
Reactions

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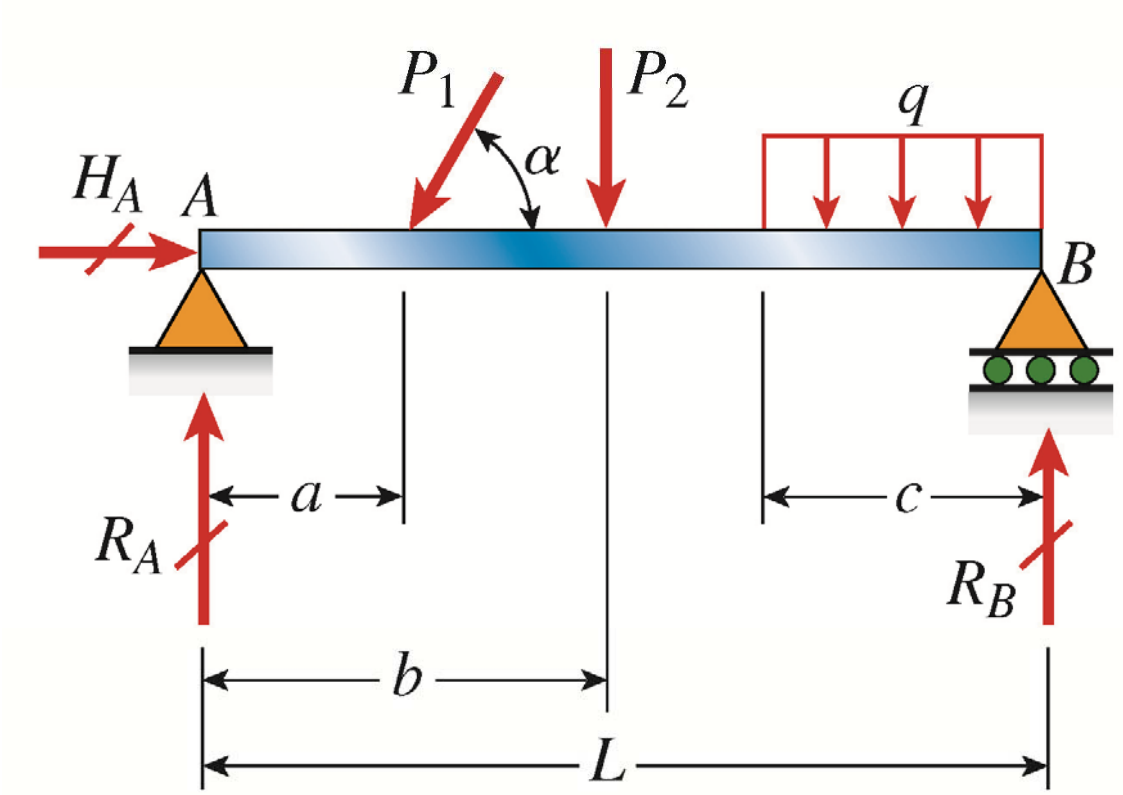
- Simple beam



Types of Beams, Loads, and Reactions
Reactions

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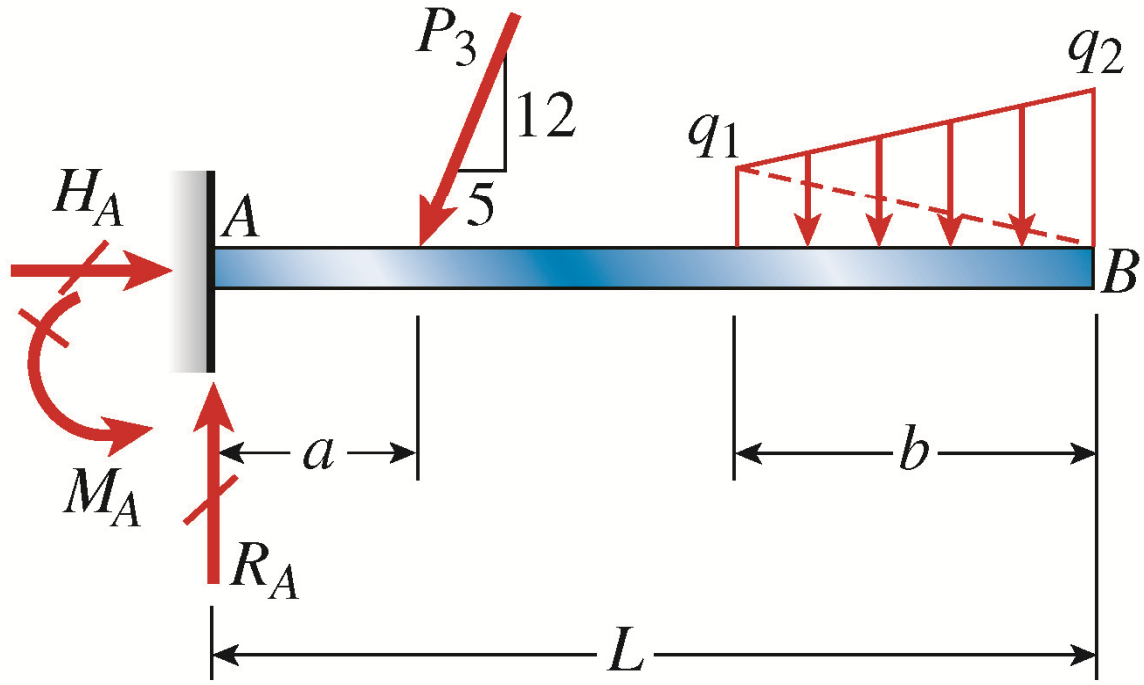
- Cantilever beam



Types of Beams, Loads, and Reactions
Reactions

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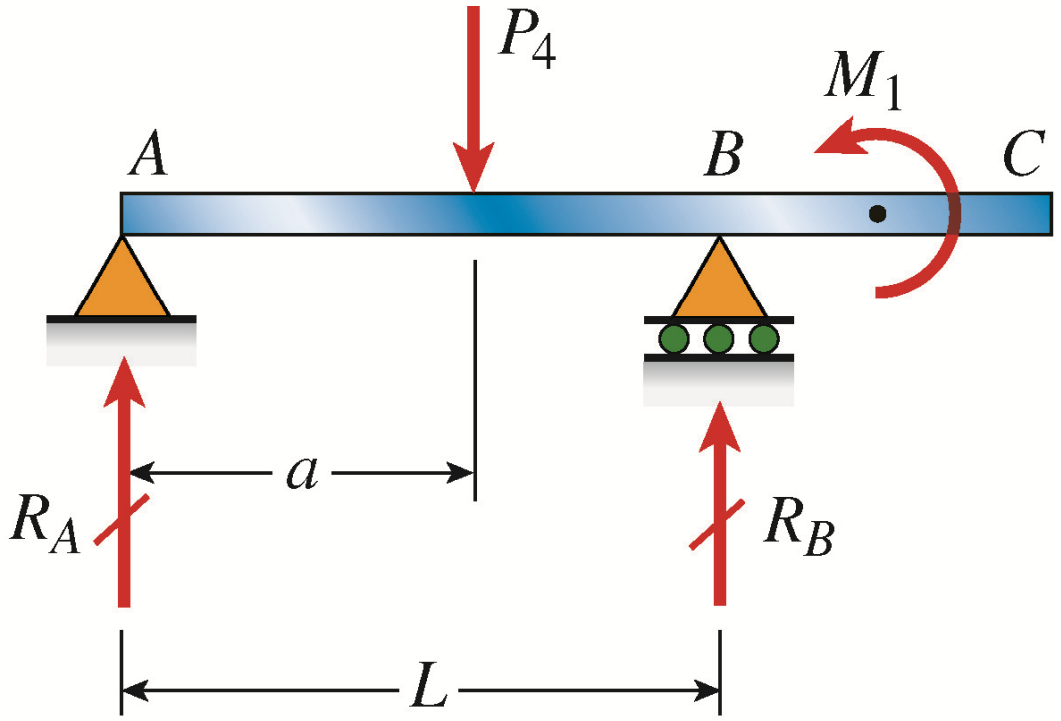
- Beam with an overhang



Shear Forces and Bending Moments
basic concepts

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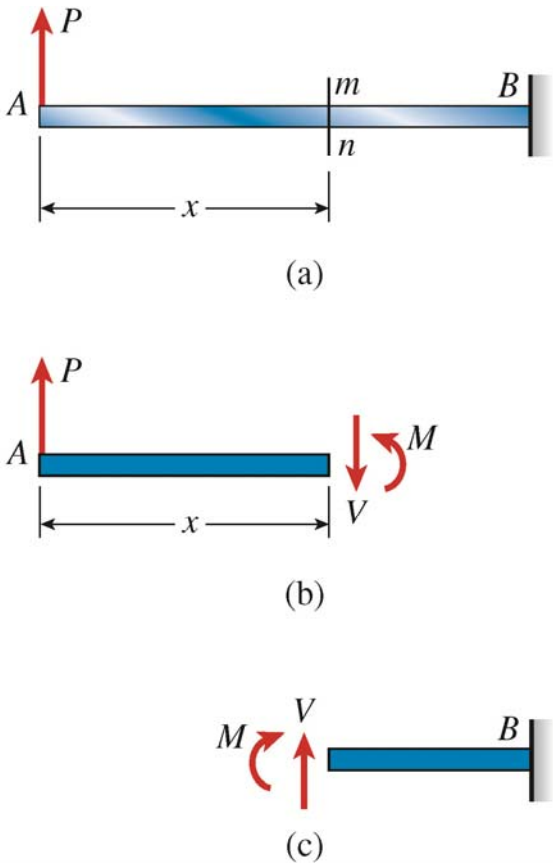
- Beams under forces or moment → stresses and strains are created throughout the interior of the beam.
- We first find the internal forces and couple (bending moment) on the cross section.
- Free Body Diagram – isolate left or right hand part.
- Stress resultant (합응력): resultants of stresses distributed over the cross section.



Shear Forces and Bending Moments methodology

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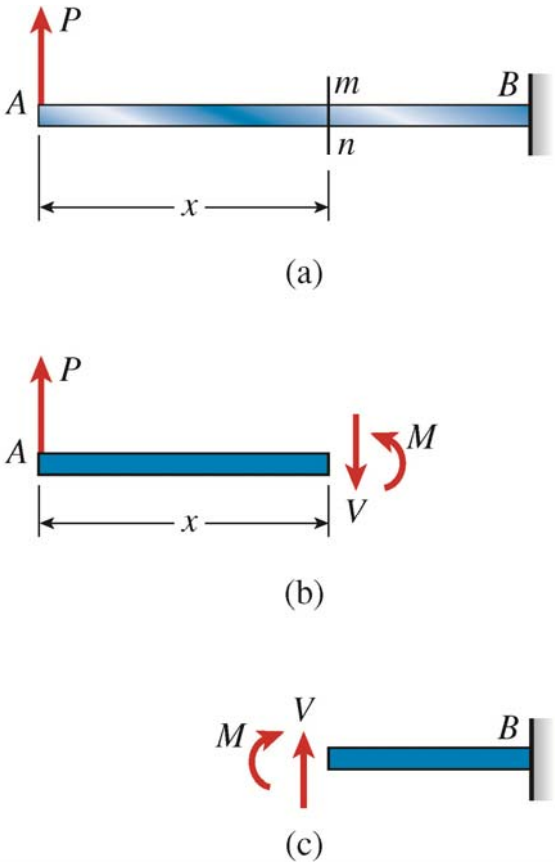
- Equilibrium Equation

$$\sum F_{ver} = 0 \qquad P - V = 0$$

$$V = P$$

$$\sum M = 0 \qquad M - Px = 0$$

$$M = Px$$



Shear Forces and Bending Moments
sign conventions for stress resultants

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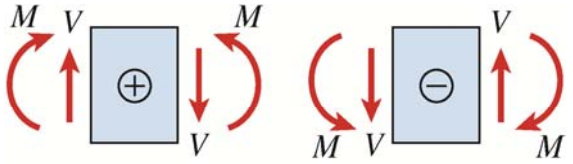
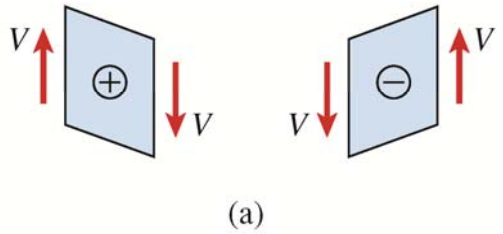
- (+) shear force: acts clockwise
- (-) shear force: …..counter-clockwise



- (+) bending moment: compress upper part
- (-) bending moment: …….. lower part



- ‘deformation sign convention’
  - Based on how the material is deformed.
- ‘static sign convention’
  - Forces/moments are (+) or (-) according to their directions

Shear Forces and Bending Moments Example 4-1

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- Shear force V & bending moment M at the right and left of mid point?
  - R_A & R_B?
  - Free Body Diagram.

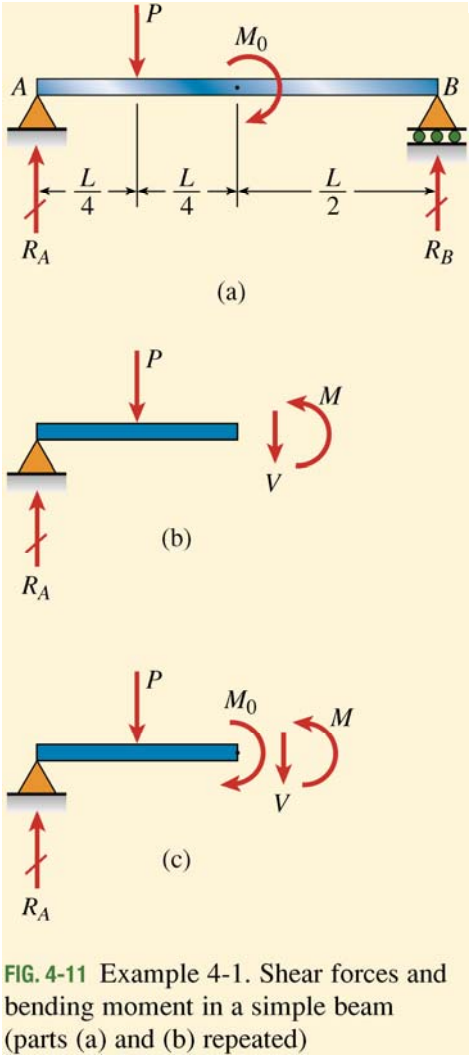

FIG. 4-11 Example 4-1. Shear forces and bending moment in a simple beam (parts (a) and (b) repeated)

Shear Forces and Bending Moments
Example 4-2

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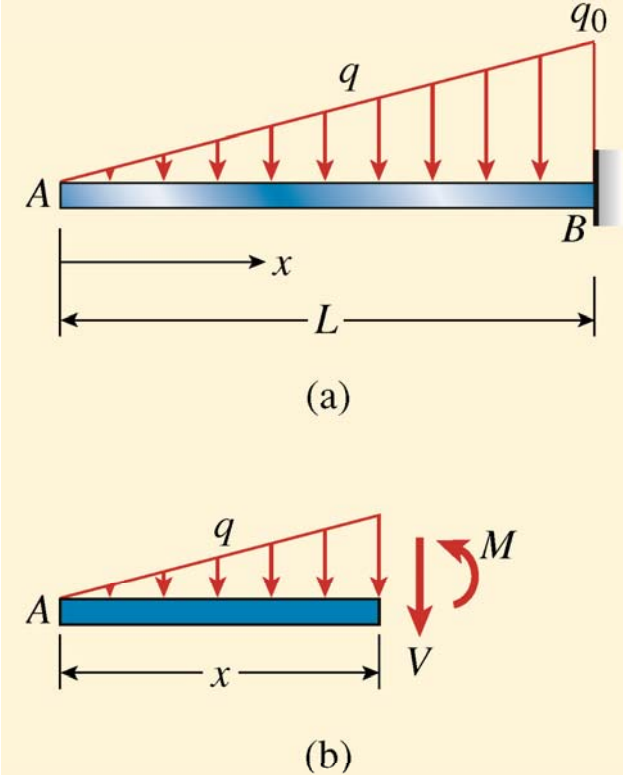
- Shear force V & Bending moment M?

$$q = \frac{q_0}{L} x$$

$$V = -\frac{q_0 x^2}{2L}$$

$$M = -\frac{q_0 x^3}{6L}$$

$$-\frac{dV}{dx} = q \qquad \frac{dM}{dx} = V$$



Shear Forces and Bending Moments
Example 4-3

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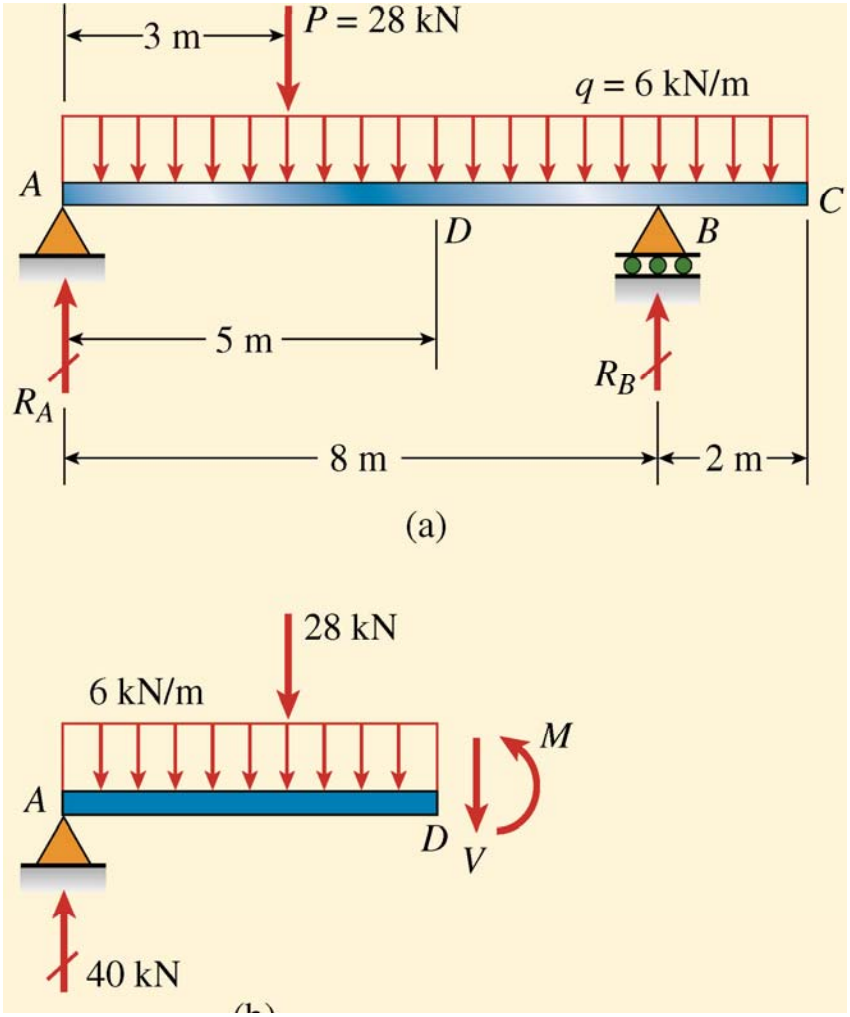
- Shear force V & bending moment M at D?



Relationships Between Loads, Shear Forces and Bending Moments

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- Useful for investigating the shear forces and bending moments throughout the entire length of a beam
- Helpful when constructing shear-force and bending-moment diagrams

Summary

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- Introduction
- Types of Beams, Loads, and Reactions
- Shear Forces and Bending Moments

- Relationships Between Loads, Shear Forces and Bending Moments
- Shear-Force and Bending-Moment Diagrams

Next Monday

This Wednesday

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- Introduction
- Centroids of Plane Areas
- Centroids of Composite Areas
- Moments of Inertia of Plane Areas
- Parallel-Axis Theorem for Moments of Inertia
- Polar Moments of Inertia