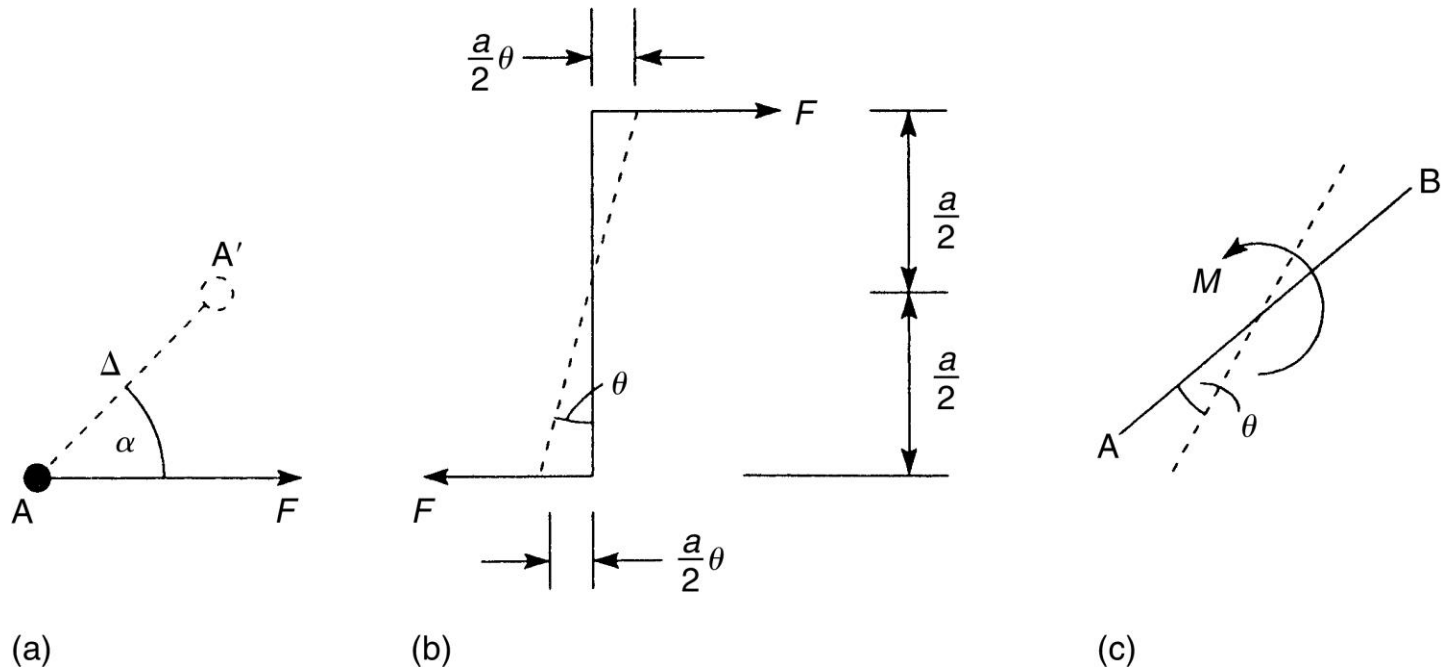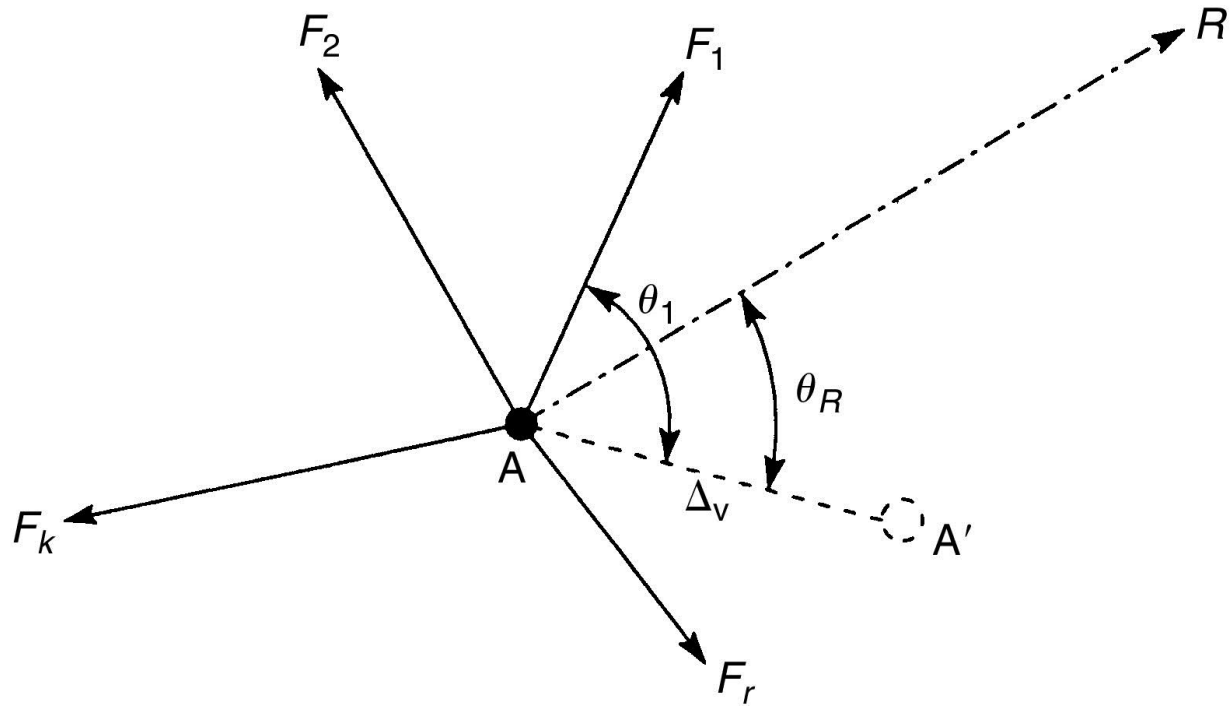# Chapter 4
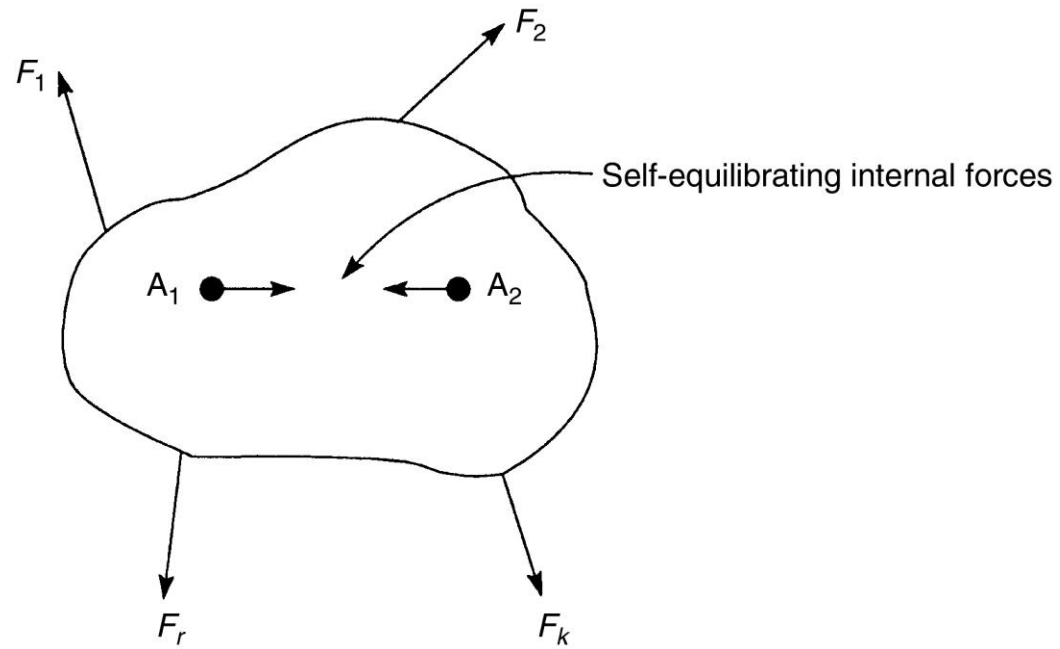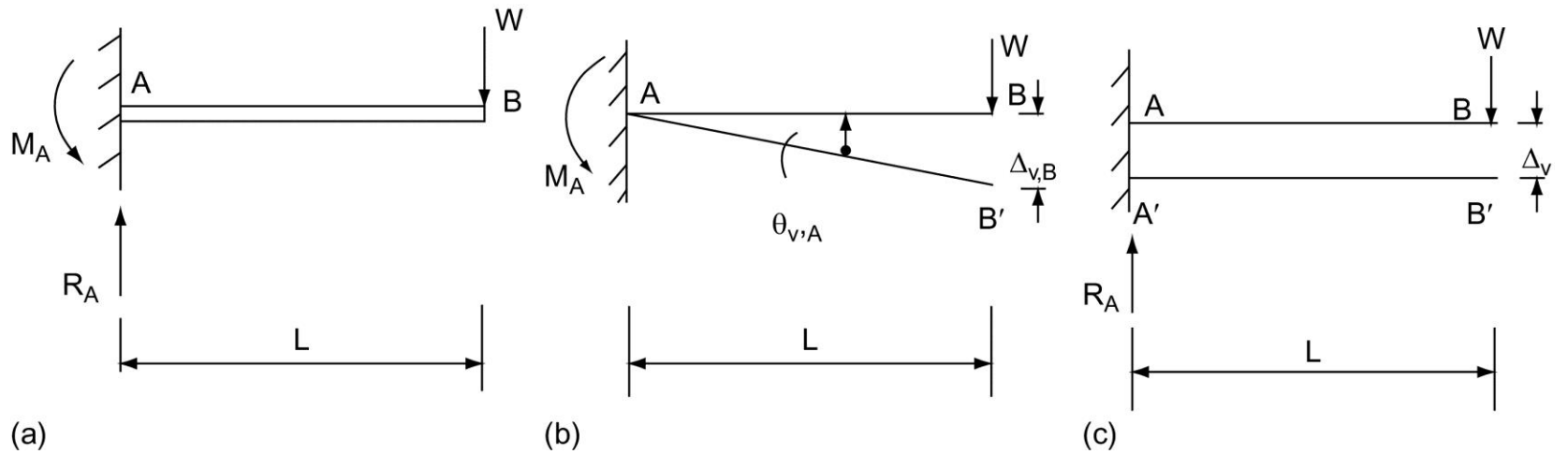# Virtual work and energy methods

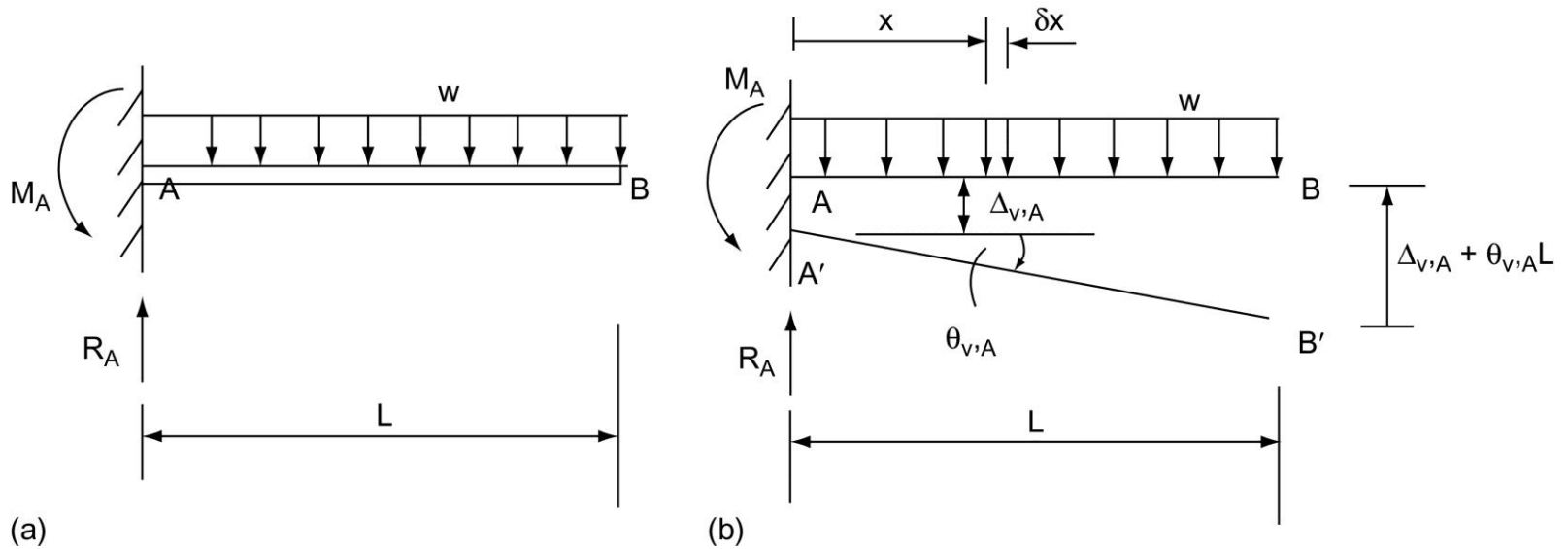**FIGURE 4.1** Work Done by a Force and a Moment

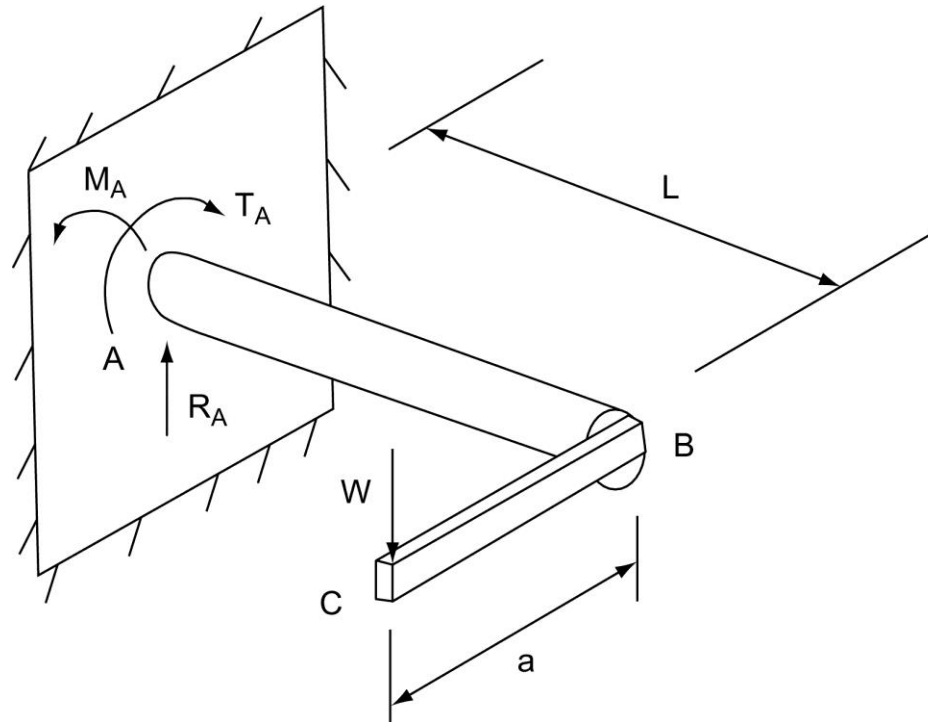**FIGURE 4.2** Virtual Work for a System of Forces Acting on a Particle

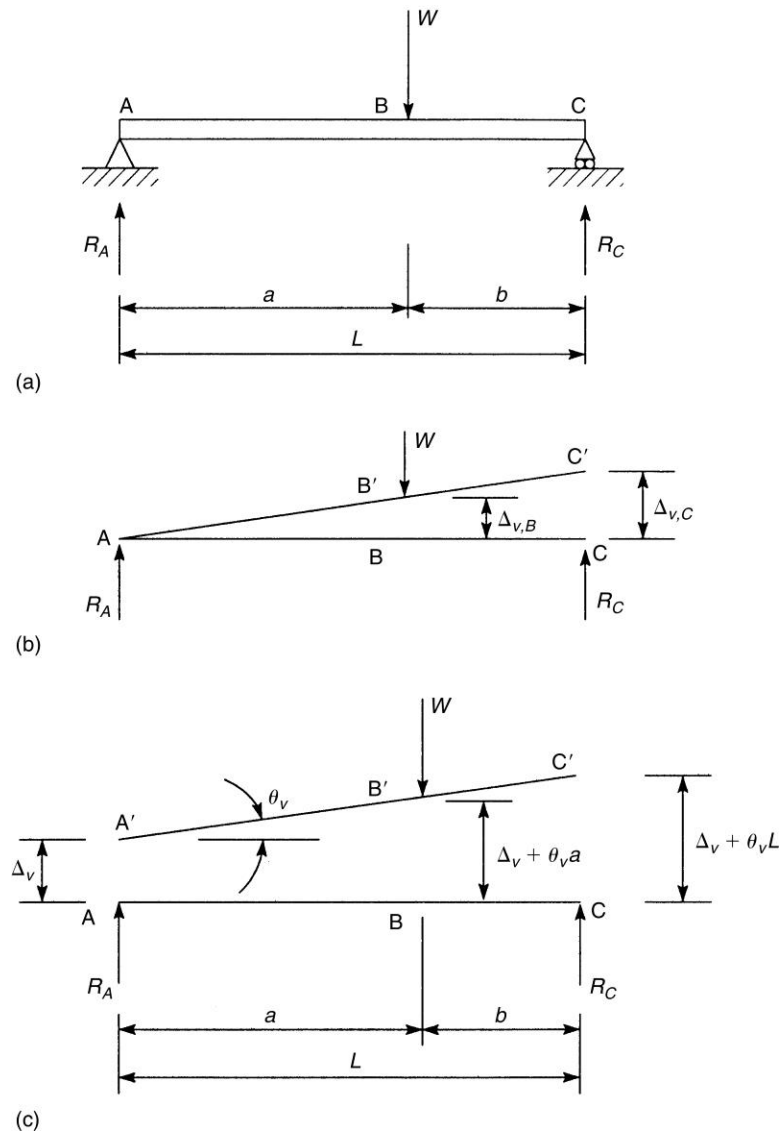**FIGURE 4.3** Virtual Work for a Rigid Body

FIGURE 4.4 Use of the Principle of Virtual Work to Calculate Support Reactions

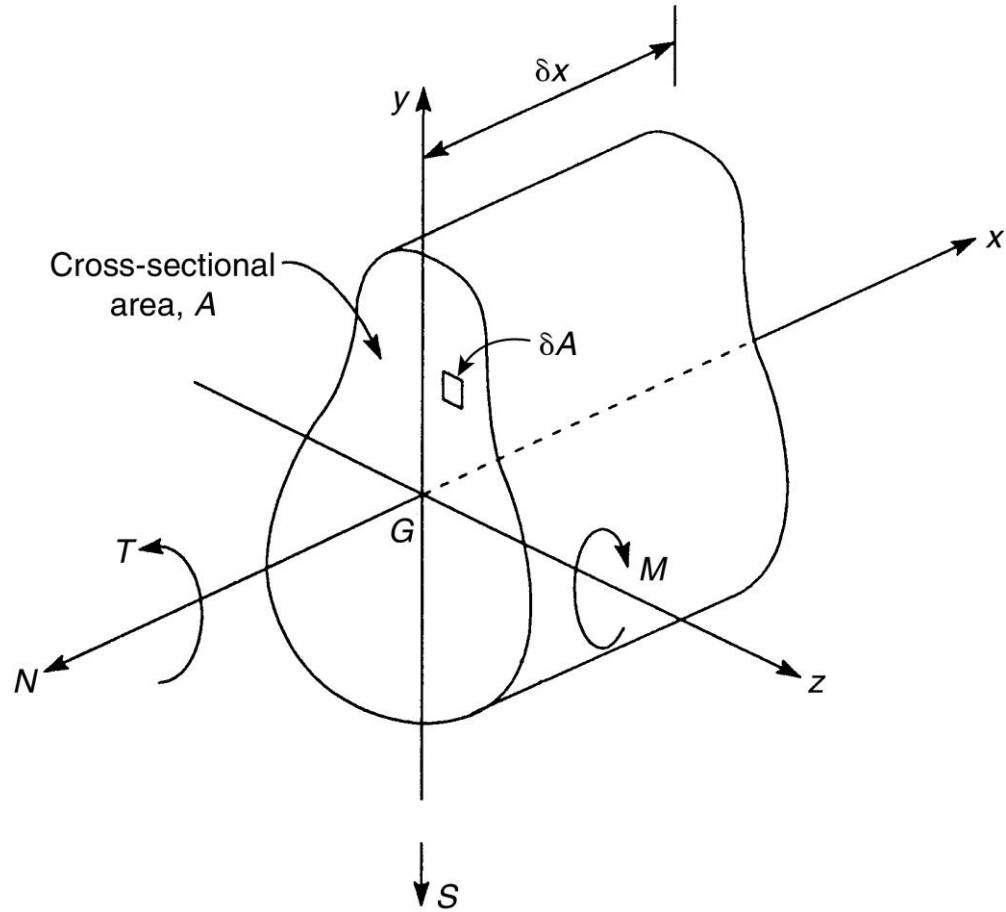**FIGURE 4.5** Calculation of Support Reactions Using the Principle of Virtual Work
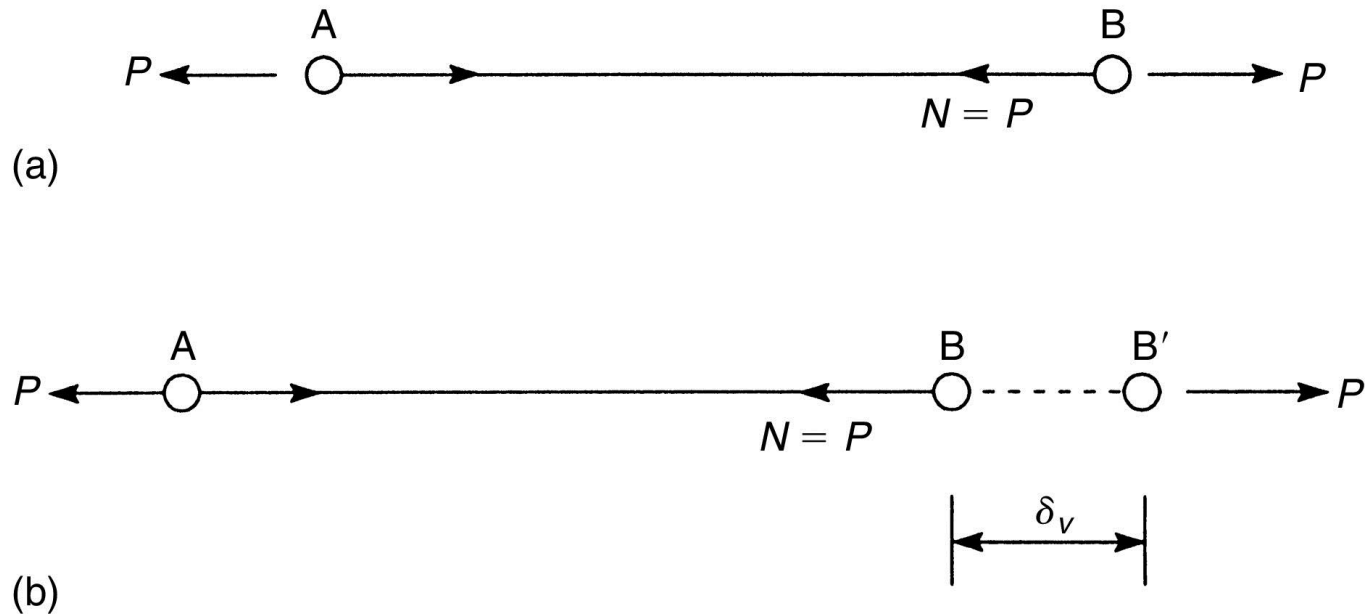
FIGURE 4.6 Beam of Example 4.3

FIGURE 4.7 Use of the Principle of Virtual Work to Calculate Support Reactions
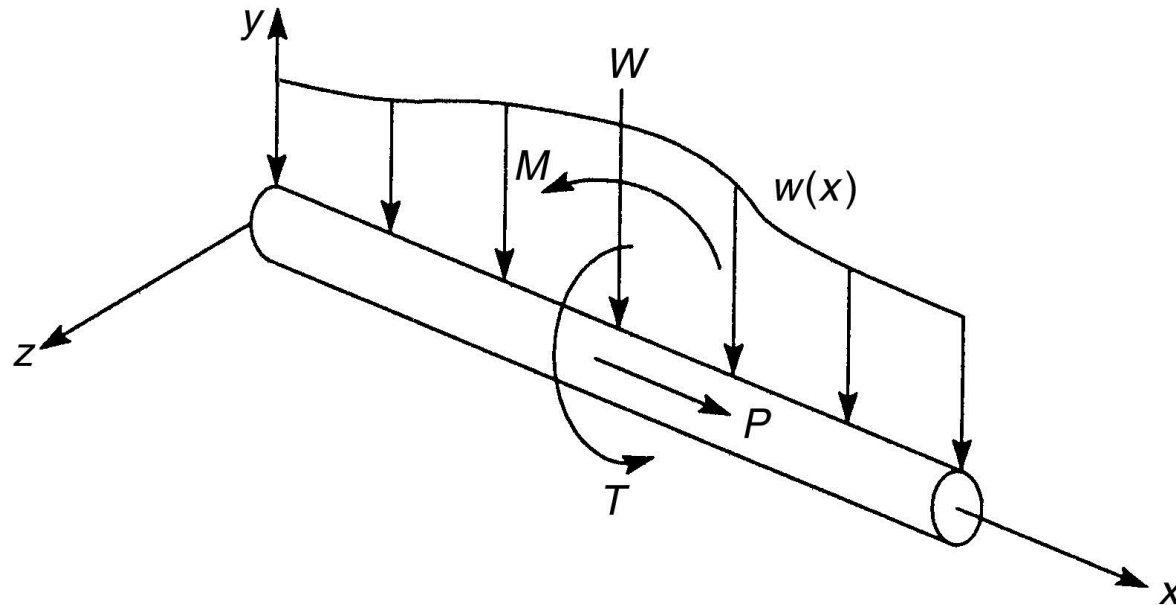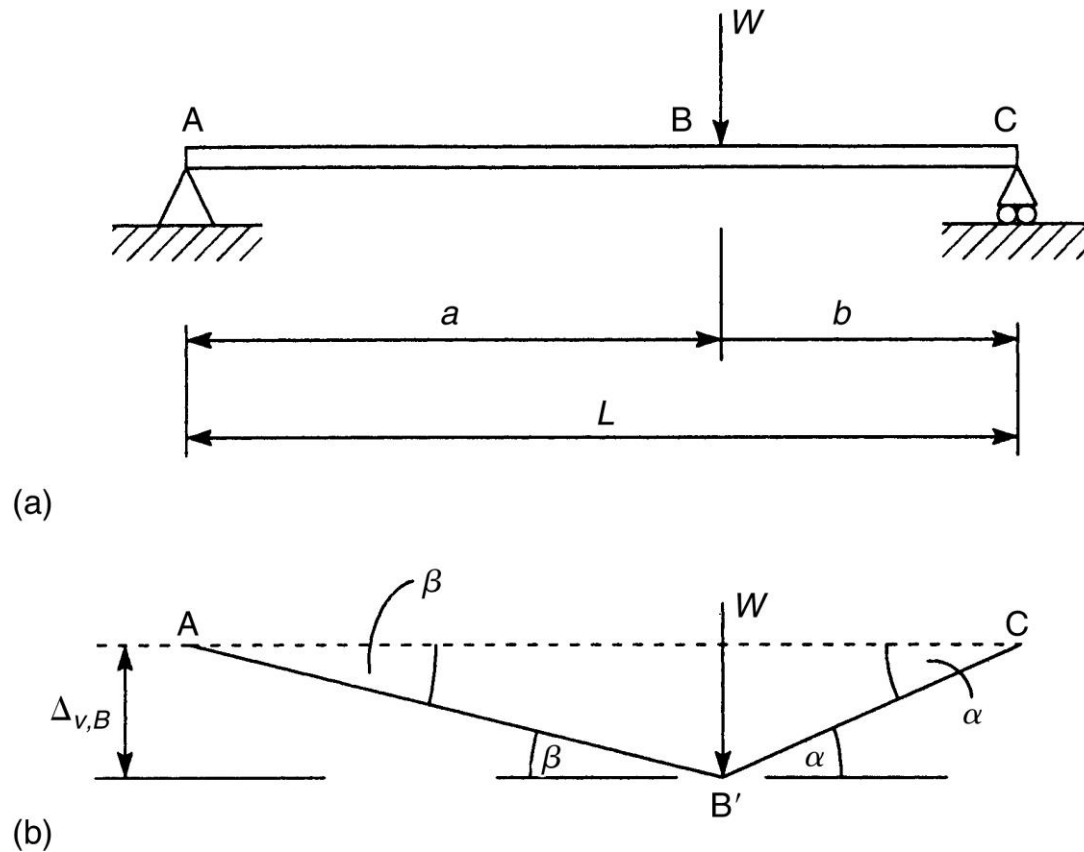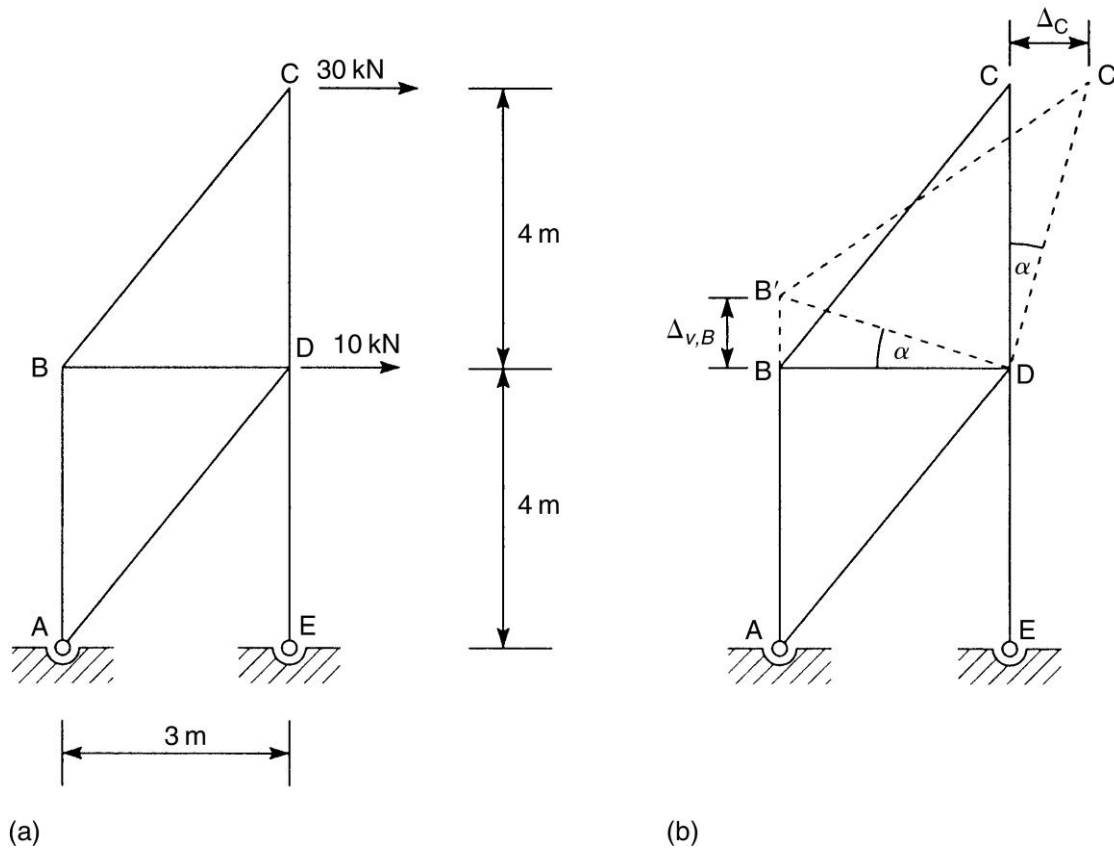
FIGURE 4.8 Virtual Work Due to Internal Force System

(a)

(b)

FIGURE 4.9 Sign of the Internal Virtual Work in an Axially Loaded Member
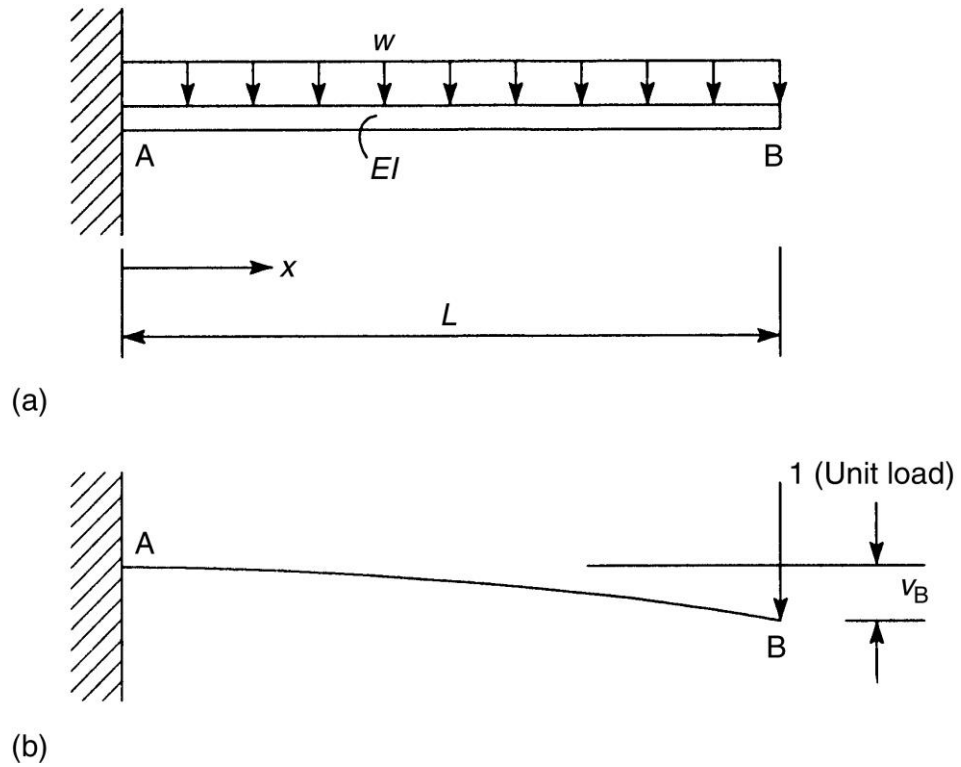
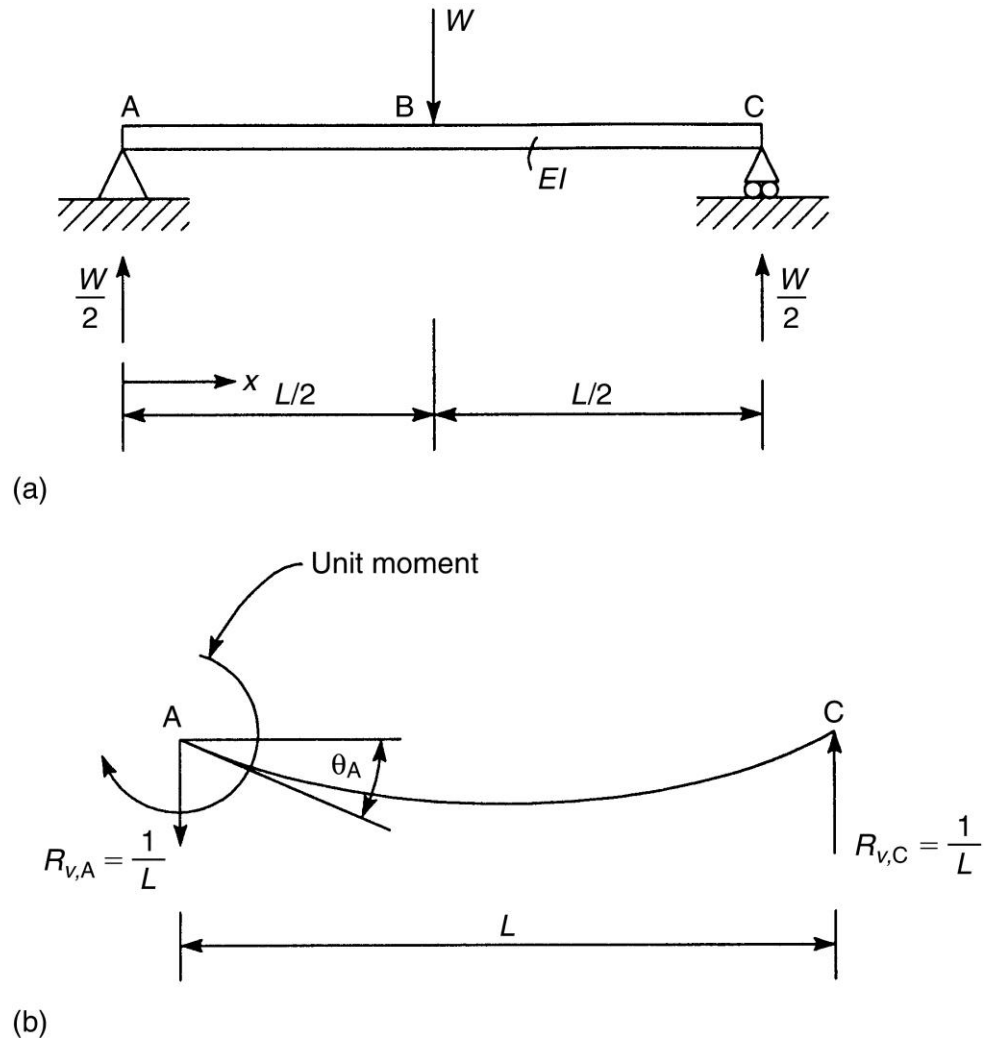**FIGURE 4.10** Virtual Work Due to Externally Applied Loads

(a)

(b)

FIGURE 4.11 Determination of Bending Moment at a Point in the Beam of Example 4.5 Using Virtual Work
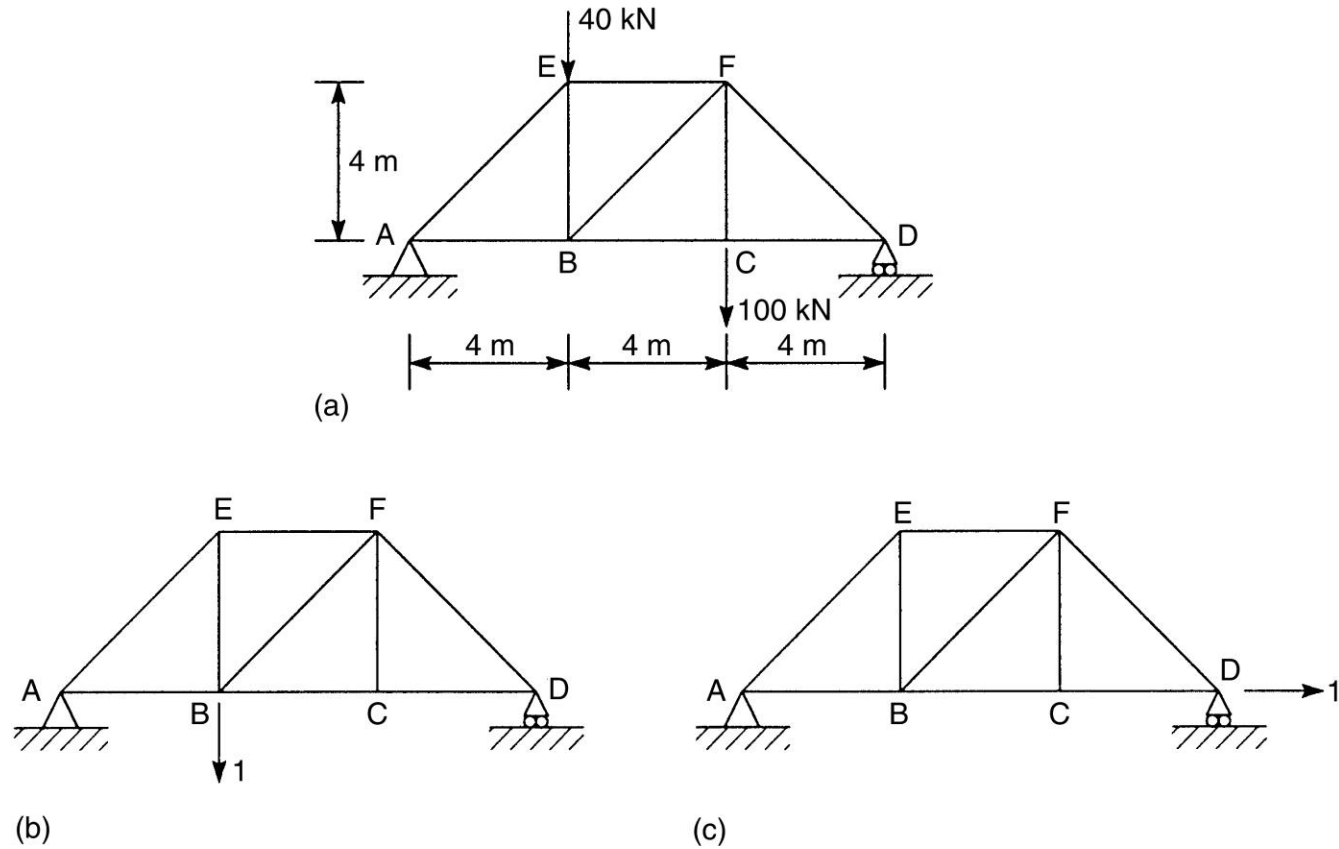
FIGURE 4.12 Determination of the Internal Force in a Member of a Truss Using Virtual Work

(a)

(b)

FIGURE 4.13 Deflection of the Free End of a Cantilever Beam Using the Unit Load Method
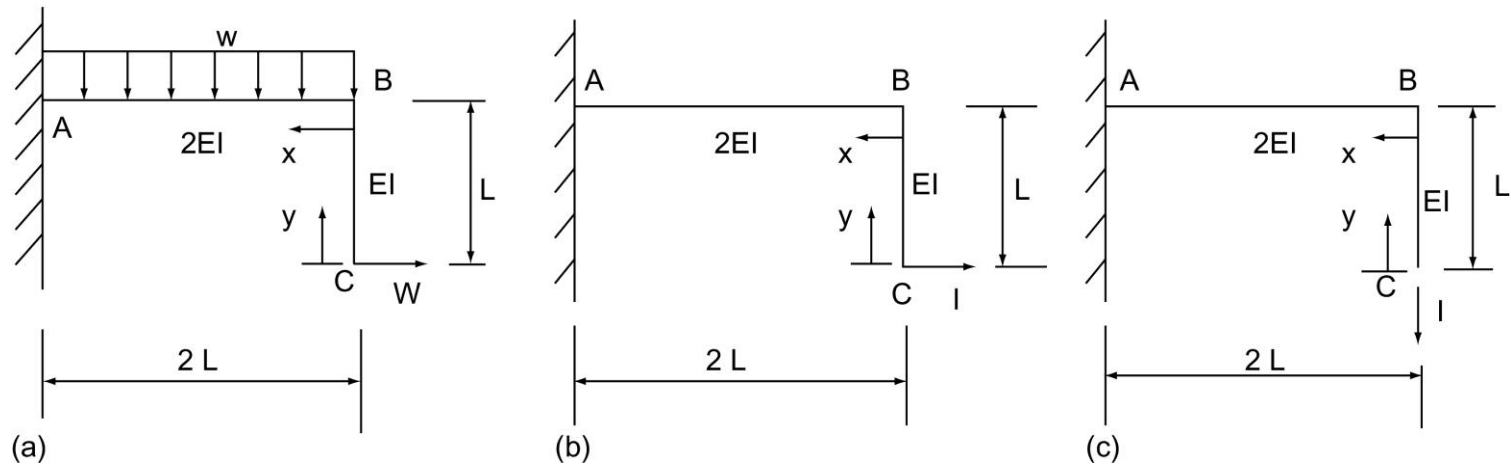
(a)

(b)

FIGURE 4.14 Determination of the Rotation of a Simply Supported Beam at a Support Using the Unit Load Method
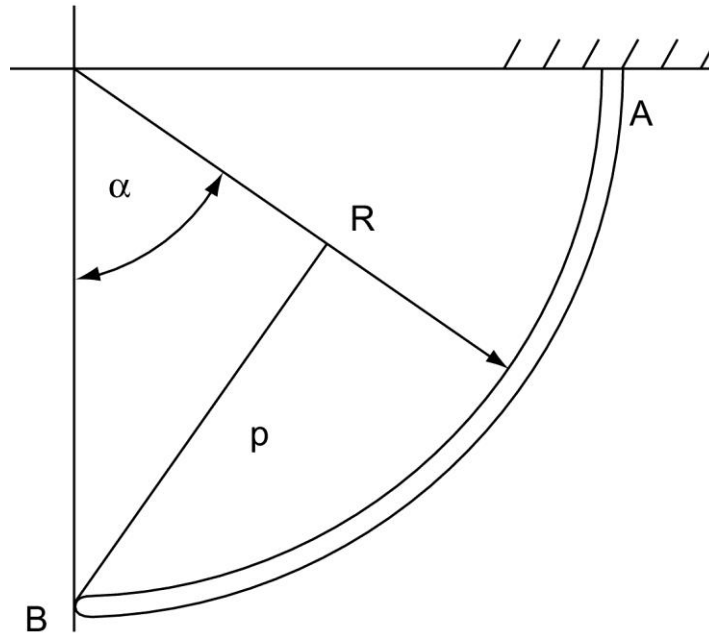
FIGURE 4.15 Deflection of a Truss Using the Unit Load Method

FIGURE 4.16 Frame of Example 4.10

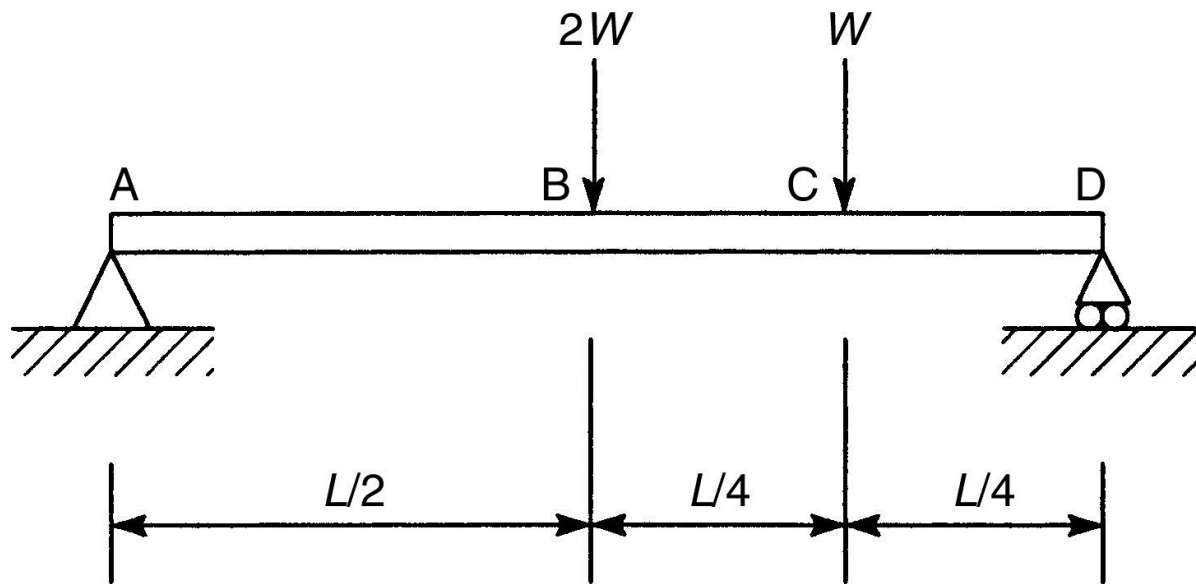**FIGURE 4.17** Cantilever Beam of Example 4.11
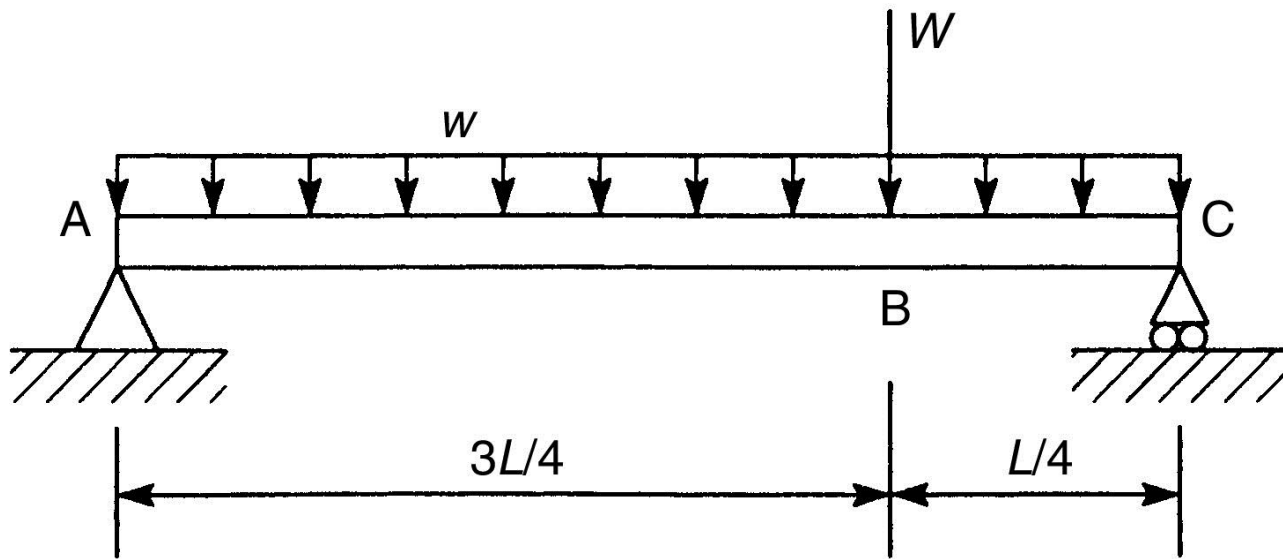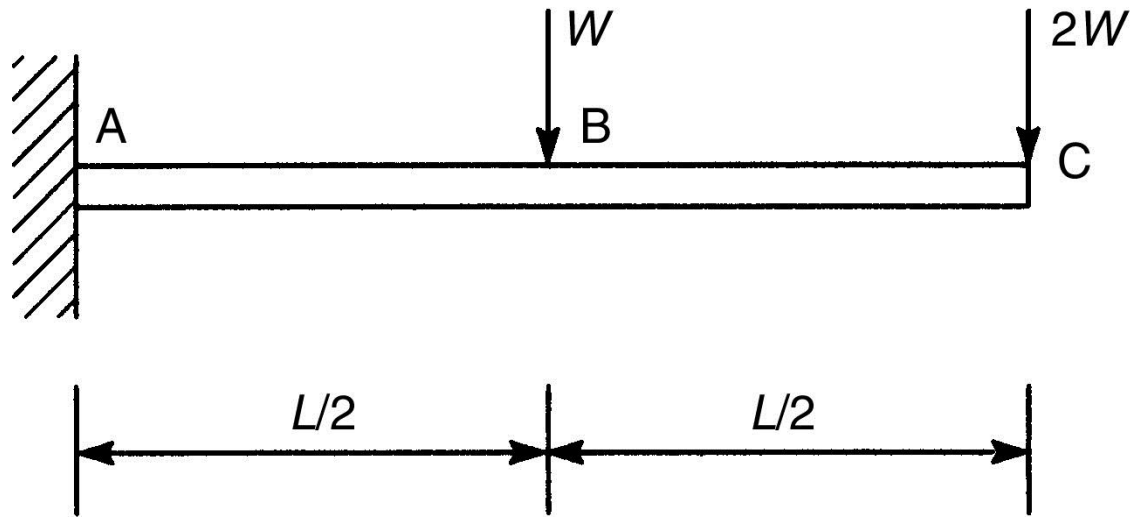
FIGURE P.4.1

FIGURE P.4.2

FIGURE P.4.3
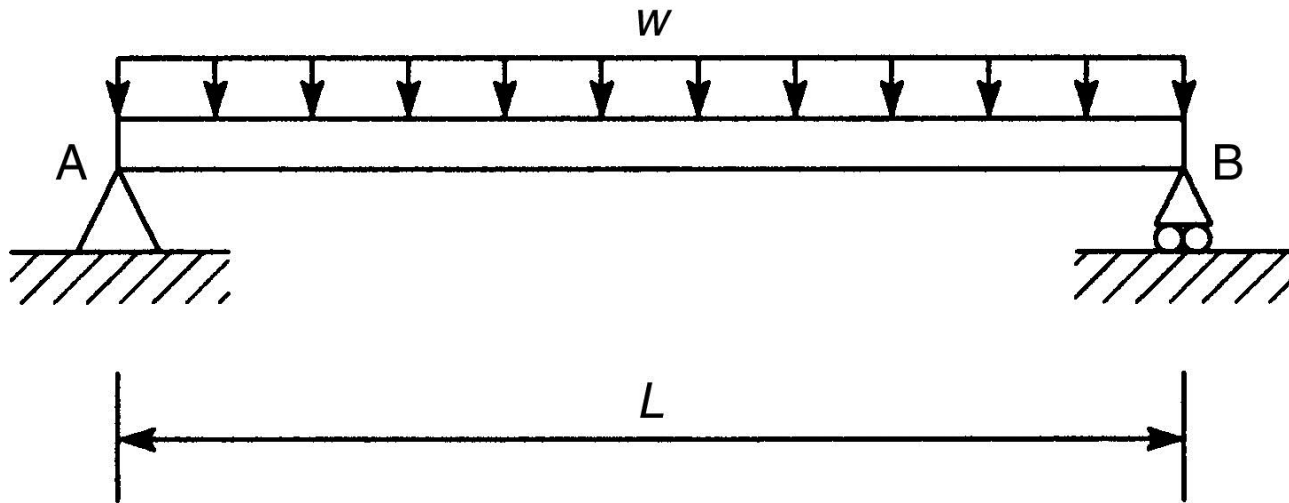
FIGURE P.4.4
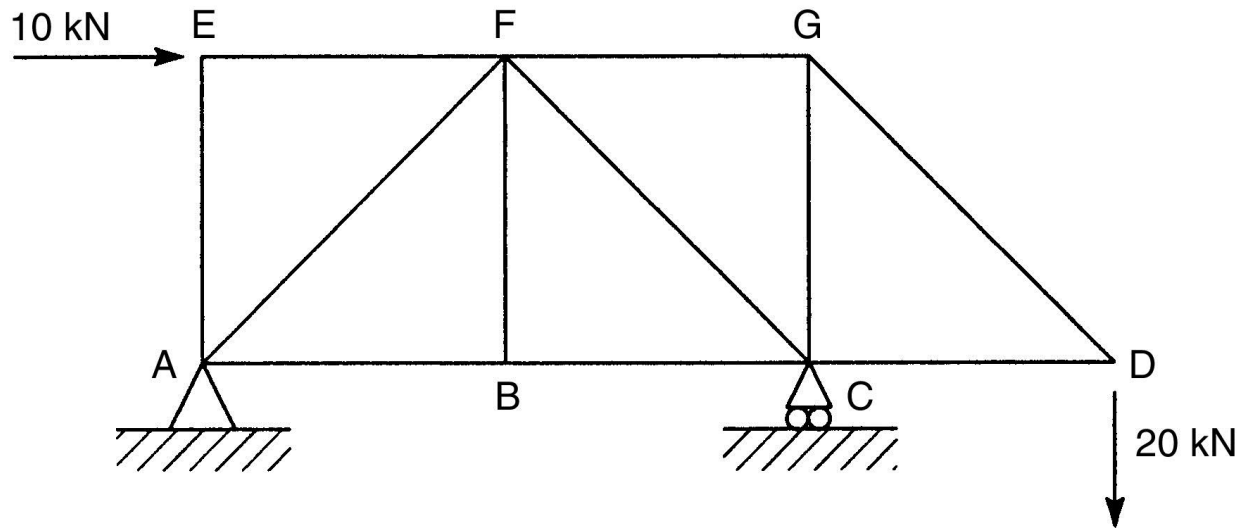
FIGURE P.4.5
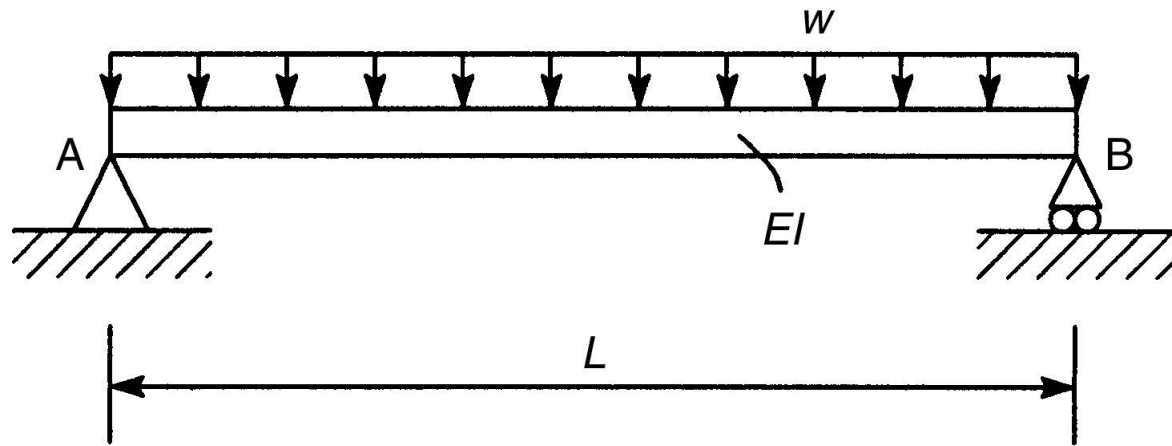
FIGURE P.4.6
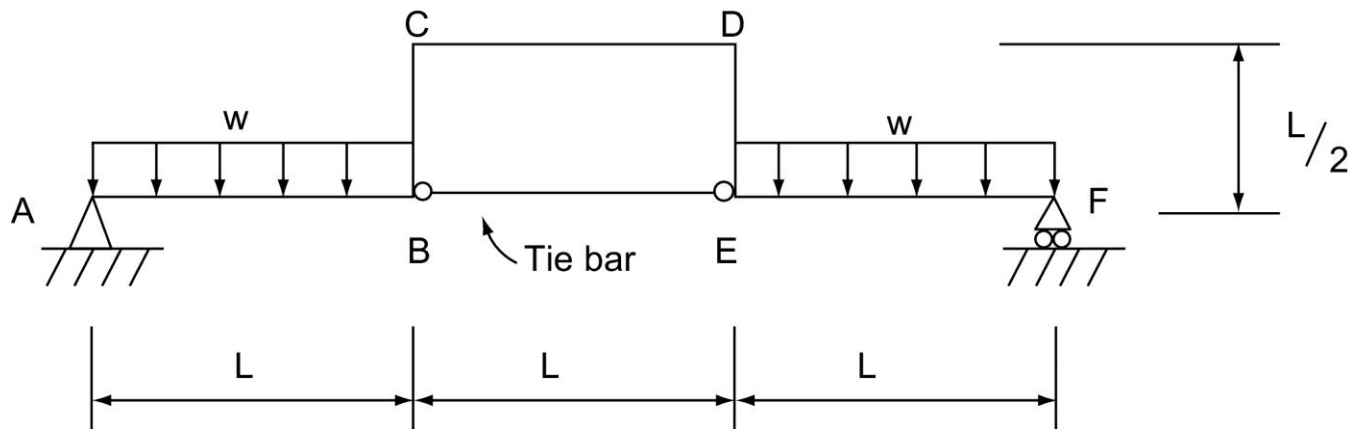
FIGURE P.4.7

FIGURE P.4.8

FIGURE P.4.9