MM 210

MECHANICS OF MATERIALS

2012-2013

1.INTRODUCTION TO MECHANICS OF MATERIALS

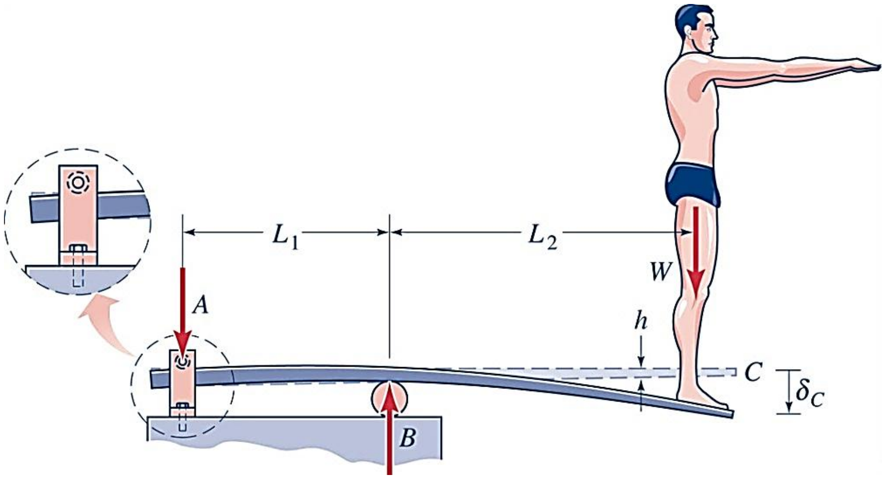
- WHAT IS MECHANICS OF MATERIALS?

Mechanics is the physical science that deals with the conditions of rest or motion of bodies acted on by forces or by thermal disturbances. The study of bodies at rest is called *statics*, whereas *dynamics* is the study of bodies in motion.

The subject ***mechanics of materials*** is a branch of mechanics that deals with the internal behavior of variously loaded solid bodies. It's also known as strength of materials, mechanics of deformable bodies or mechanics of solids.

The solid bodies referred to here include shafts, bars, beams, plates, shells, columns as well as structures and machines that are assemblies of these components.

We can begin to answer the question, "What is mechanics of materials?" by considering diving board in the figure. Whereas it would be possible from rigid-body equilibrium alone, given the weight of the diver and the lenghts L_1 and L_2, to determine the diving-board support reactions at *A* and *B* in the figure, questions of the following type can only be answered by employing the principles and procedures of mechanics of materials.



1.What weight W would cause the given diving board to break, and where would the break occur?

2.Would a diving board made of fiberglass be prefereable to one made of aluminum?

3.For a given diving board and position of roller B, what is the relationship between the tip deflection at C and the weight W?

4.Would a tapered diving board be better than one of constant thickness? If so, how should the thickness, *h*, vary from *A* to *C*?

Roy R. Craig, Jr.

Stress and deflection analysis and *mechanical properties of materials* are the main aspects of the Mechanics of Materials.

In the design of any structure or machine, it is first necessary to use the principles of statics to determine the forces acting both on and within its various members.

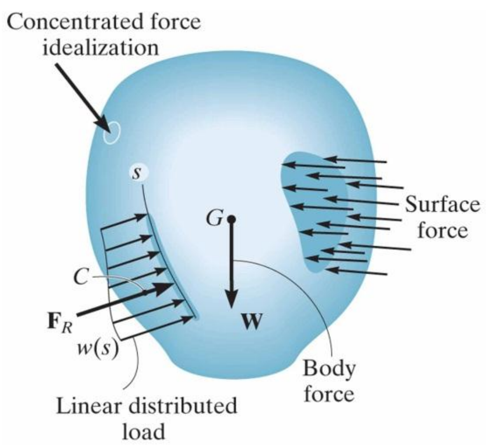
Design (the size of members, their deflection) depends not only on the internal loadings, but also on the type of material from which the members are made.

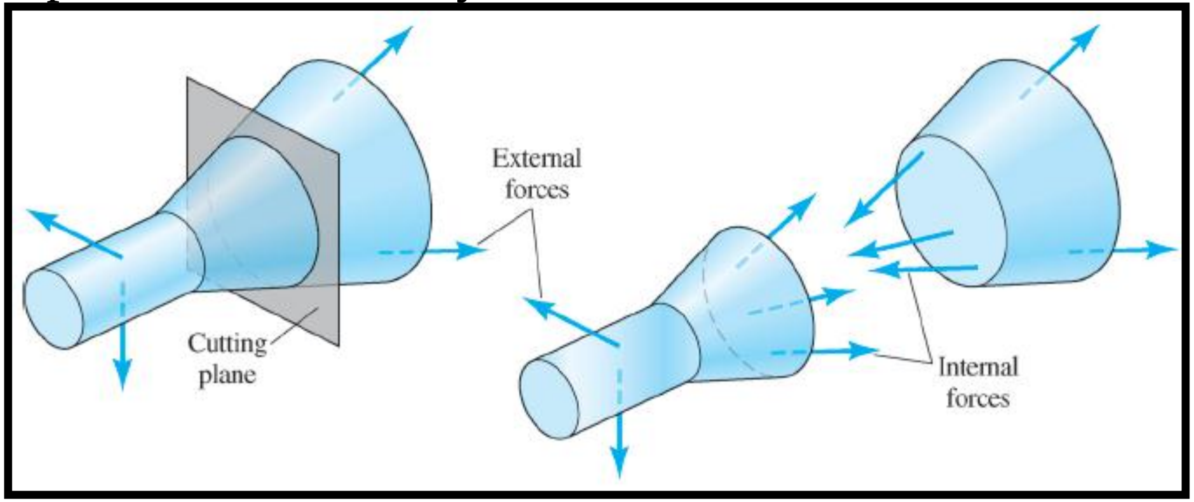
- **REWIEW OF STATIC EQUILIBRIUM**

Since statics plays an important role in both the development and application of Mechanics of Materials, so we have to know basic principles of statics.

Types of loads: External loads and Internal loads

- *External loads* are due to surface forces and body forces
  - Surfaces forces can be for example, a concentrated load acting at a point or a distributed load both acting on the surface of a body
  - Body forces act on a volumetric portion of the body, for example, magnetic force or gravitational force
  - Reaction forces caused by the supports
- *Internal loads* can be considered as forces of interaction between the constituent material particles of the body

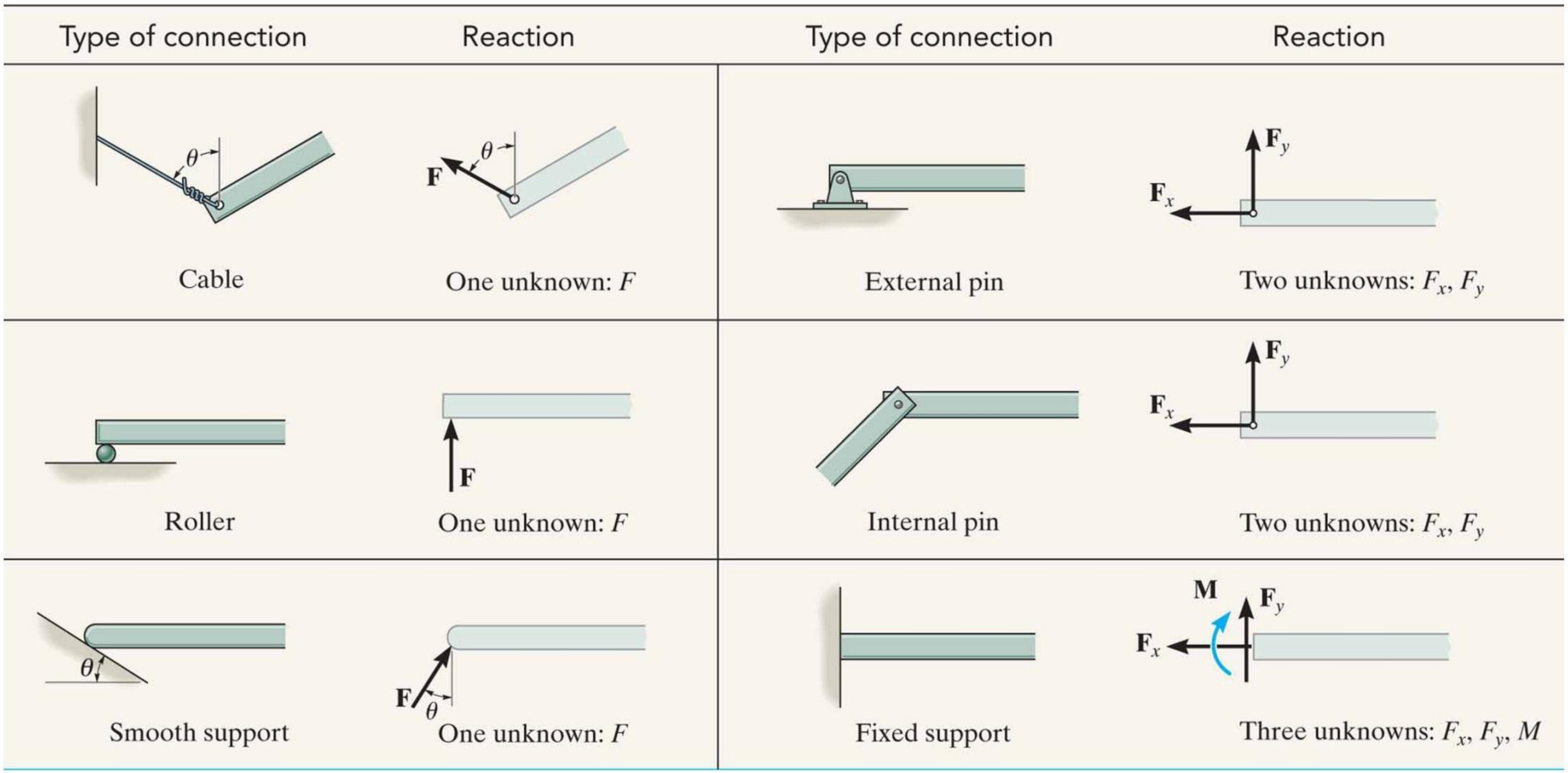




- # SUPPORT REACTIONS

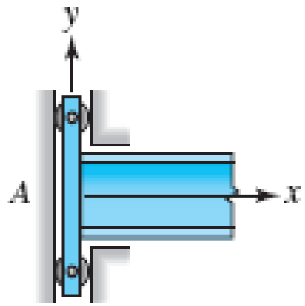
The surface forces that developed at the supports or points of contact between bodies are called **reactions**.

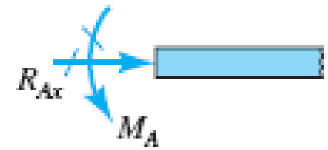
If the support prevents translation in a given direction, then a force must be developed on the member in that direction. Likewise, if rotation is prevented, a couple moment must be exerted on the member.



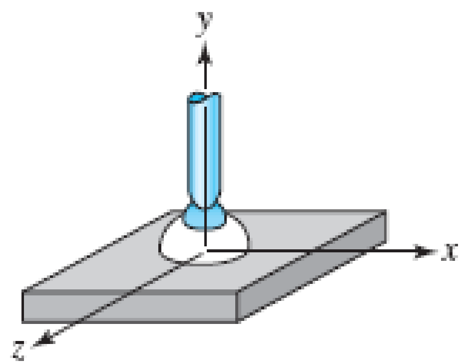
Hibbeler

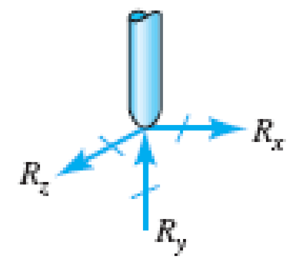
. Guided



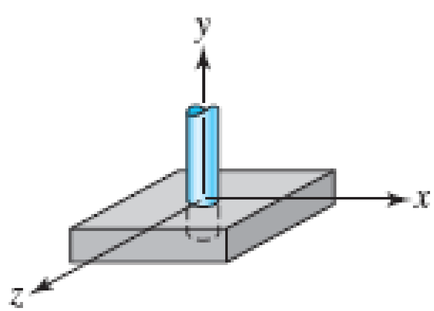


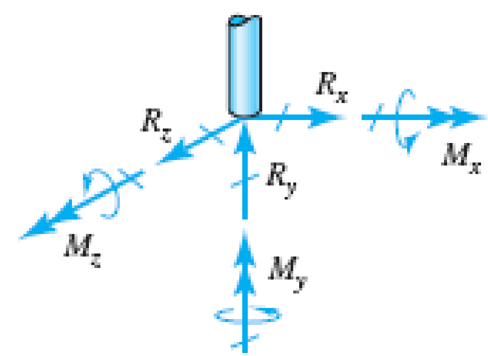
. Ball and socket (nonplanar)





. Fixed (nonplanar)





- CONDITIONS OF EQUILIBRIUM

- When a system of forces acting upon a body has zero resultant, the body is said to be in force equilibrium.

- The equations of static equlibrium require;

$$\sum F_x = 0; \sum F_y = 0, \text{ and } \sum F_z = 0;$$

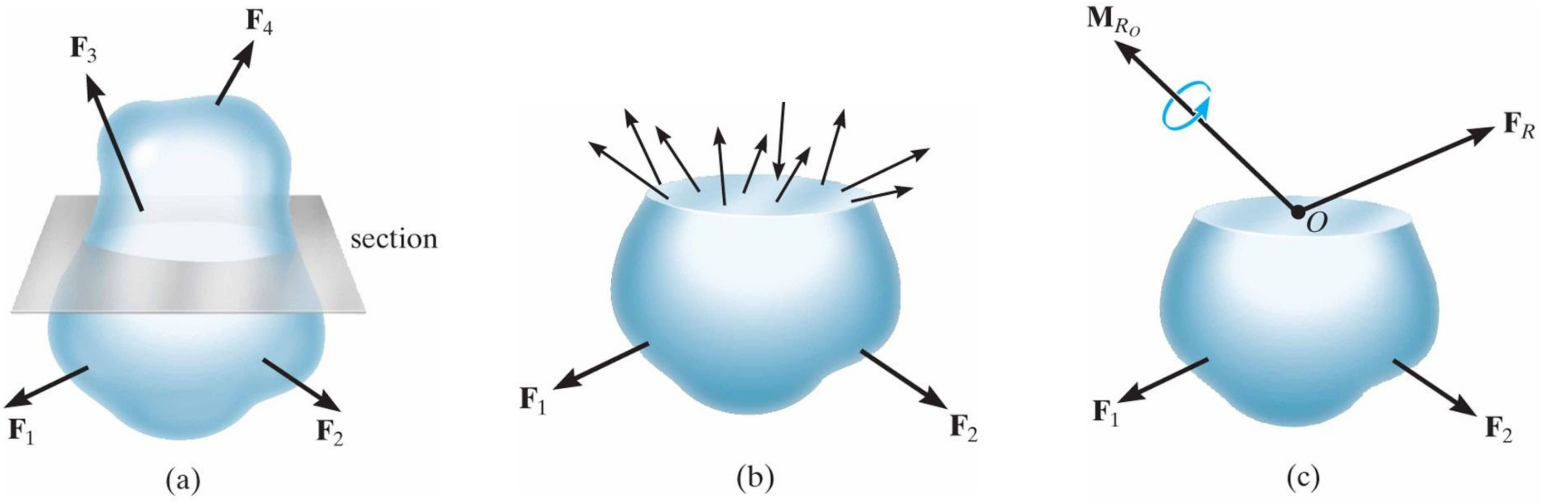
$$\sum M_x = 0; \sum M_y = 0, \text{ and } \sum M_z = 0$$

- In other words, for a body to be in static equilibrium, the sum of all forces acting upon a body in any direction is zero and also the sum of all moments taken about any axis is also zero.

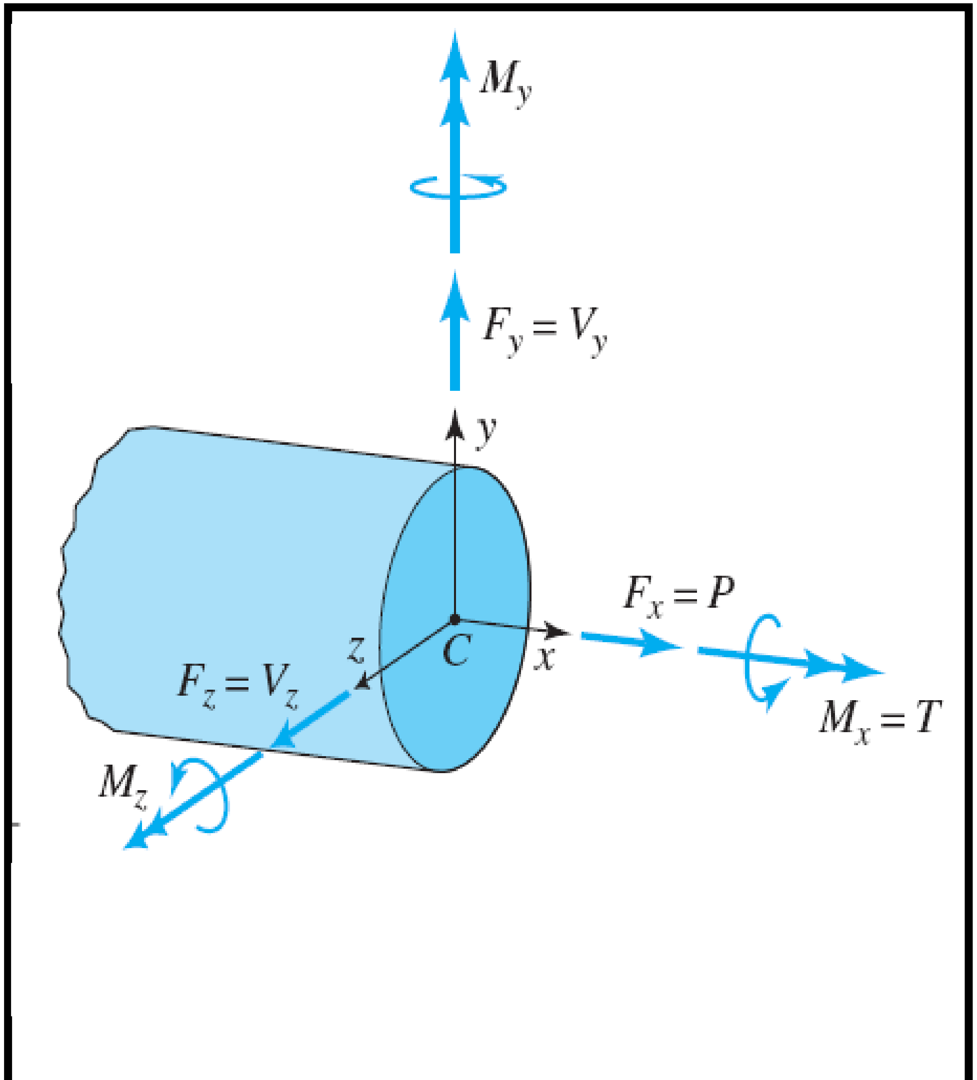
INTERNAL FORCE RESULTANTS

A body responds to the application of external forces by deforming and by developing an internal force system (forces and moments) that holds together the particles forming the body.

1. Isolate the bodies. Sketch the isolated body and show all external forces acting on it: draw a free-body diagram. *Apply the equations of equilibrium to the diagram to determine the unknown external forces.
2. Cut the body at a section of interest by an imaginary plane, isolate one of the segments, and repeat step * for that segment. If the entire body is in equilibrium, any part of it must be in equilibrium. That is, there must be internal forces transmitted across the cut sections.



Components of internal loadings



- $F_x = P$ is called the normal force
- V is called the shear force

  V_y, V_z
- $M_x = T$ is called the torsional moment or torque
- M_y, M_z are called bending moment

Free-body Diagrams

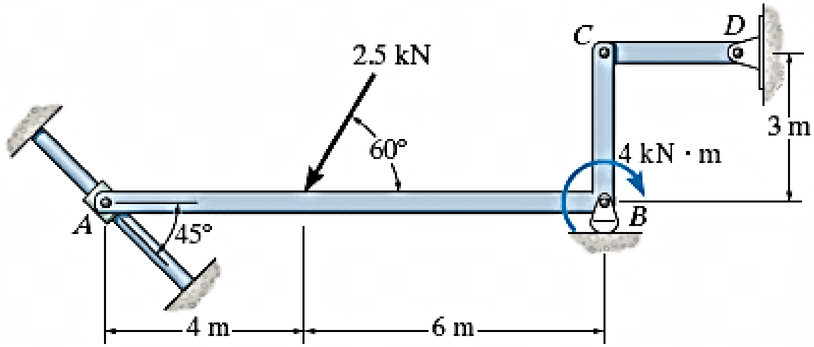
1. Select the free body to be used.

2. Detach this body from its supports and separate it from any other bodies. (If internal force resultants are to be found, use the method of sections).

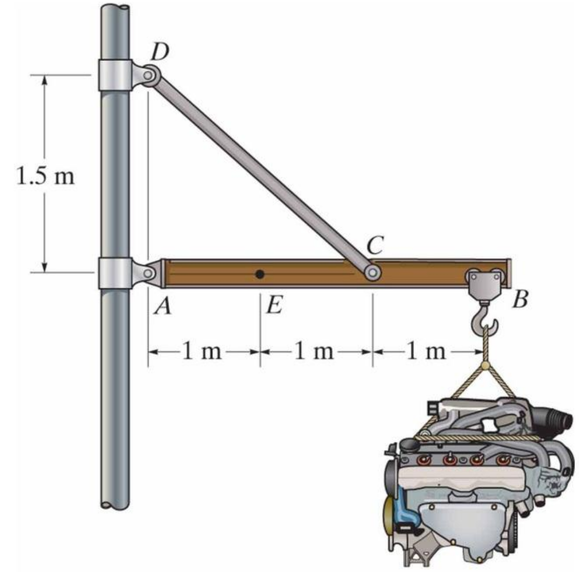
3. Show on the sketch all of the external forces acting on the body. Location, magnitude, and direction of each force should be marked on the sketch.

4. Label significant points and include dimensions. Any other detail, however, should be omitted

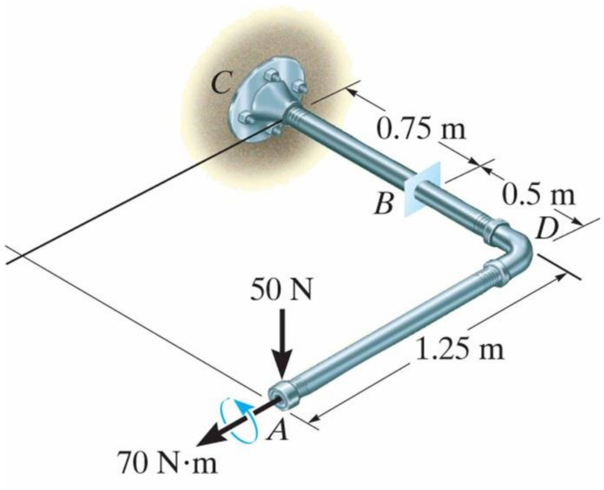
Example 1.1 Determine the normal reactions at *A* and *B* and the force in link *CD* acting on the member in the figure



Example 1.2 The 500 kg engine is suspended from the crane boom İn the Figure. Determine the resultant internal loadings acting on the cross section of the boom at point *E*.



Example 1.3 Determine the resultant internal loadings acting on the cross section at *B* of the pipe shown in Figure. The pipe has a mass of 2 kg/m and is subjected to both a vertical force of 50 N and a couple moment of 70 N.m at its end *A*. It is fixed to the wall at *C*.



Example 1.4 Determine the internal normal force, shear force and bending moment at point C in the beam.