University of Cihan-Sulaimaniya
Engineering Faculty
Architectural Engineering Department

ENGINEERING MECHANICS

Chapter 4: Force System Resultants

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Chapter Description

- Aims
  - To explain the Moment of Force (2D-scalar formulation & 3D-Vector formulation)
  - To explain the Principle Moment
  - To explain the Moment of a Couple
  - To explain the Simplification of a Force and Couple System
  - To explain the Reduction of Simple Distributed Loading

- Expected Outcomes
  - Able to solve the problems of MOF and COM in the mechanics applications by using principle of moments

- References
  - Russel C. Hibbeler. Engineering Mechanics: Statics & Dynamics, 14th Edition

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Chapter Outline

1. Moment of Force (MOF) –Part I
2. Principle of Moment –Part II
3. Moment of Couple (MOC) Part III
4. Simplification of a Force and Couple System
5. Reduction of Simple Distributed Loading- part IV

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4.1 Moment of a Force

- Moment can be defined as turning force

- The tendency of a force to rotate a rigid body about any defined axis is called the moment of the force about the axis

- It is also called a torque or twist moment that tendency of a force to rotate a body about the axis

- It is a vector, so its has both magnitude and direction (right handrule)

- +ve CCW & -ve CW

- Unit used is N.m

- In a 2-D case, the magnitude of the moment

What is Moment?

Perpendicular distance between the point about which the moment is required and the line of action of force
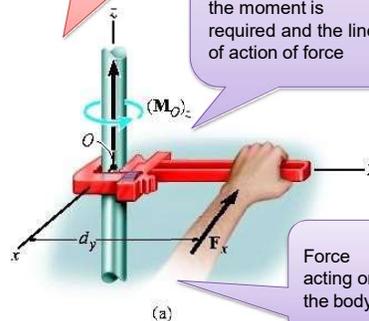
Force acting on the body

$M_o = F \, d$

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Application of Moment (turning effect)

Moment factor

Moment of a force in 2-D (scalar formulation)

Magnitude	Direction
• $M_O = Fd$ • d is the perpendicular distance from point O to the line of action of the force	• Direction of M_O is specified by using "right hand rule" • direction of M_O is either clockwise (CW) or counter-clockwise (CCW), depending on the tendency for rotation

$$M_O = F\,d$$

direction is counter-clockwise.

$$M_{Ro} = \sum Fd$$

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Moment of a force in 2-D (scalar formulation)

Moment of a force does not always cause rotation

Force F tends to rotate the beam clockwise about A with moment

$$M_A = F\,d_A$$

Force F tends to rotate the beam clockwise about B with moment
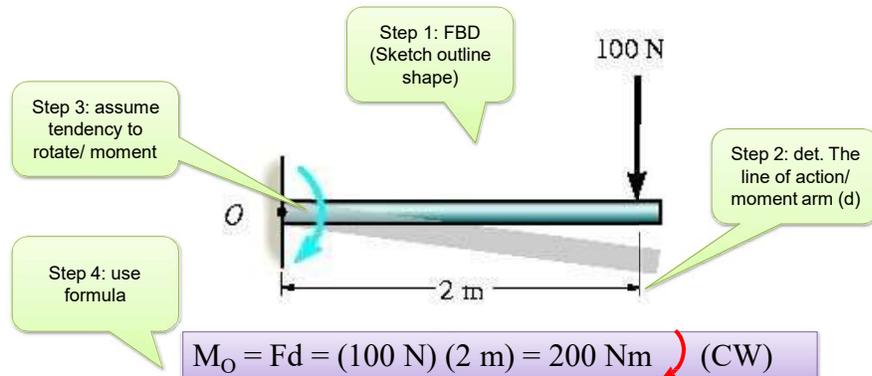
$$M_B = F\,d_B$$

$M_A = Fd_A$ $M_B = Fd_B$

Hence support at A prevents the rotation

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Example 4.1

This is an example of a 2-D or coplanar force system. Determine the MOF about point O

Step 1: FBD (Sketch outline shape)

Step 3: assume tendency to rotate/ moment

Step 2: det. The line of action/ moment arm (d)

100 N

O

Step 4: use formula

2 m

$$M_O = Fd = (100 \text{ N}) (2 \text{ m}) = 200 \text{ Nm} \quad \text{(CW)}$$

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Solution Example 4.1

This is an example of a 2-D or coplanar force system. Determine the MOF about point O

2 m

O

0.75 m

50 N

(b)

$$M_O = Fd = (50 \text{ N}) (0.75 \text{ m}) = 37.5 \text{ Nm} \quad \text{(CW)}$$

Step 2: det. The line of action/ moment arm (d)

2 m

30° 40 N

O

4 m

2 cos 30° m

$$M_O = Fd = (40 \text{ N}) (4 \text{ m} + 2 \cos 30° \text{ m}) = 229 \text{ Nm} \quad \text{(CW)}$$
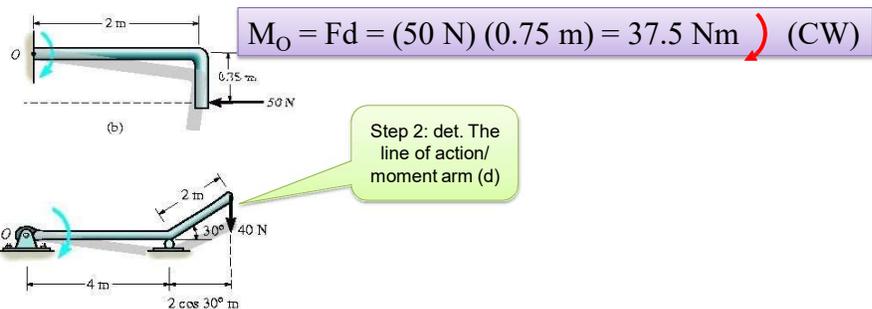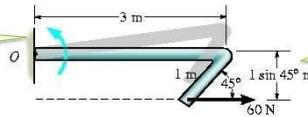
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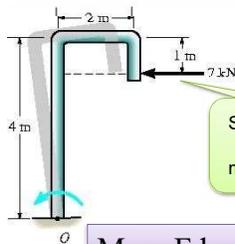
Solution Example 4.1

This is an example of a 2-D or coplanar force system. Determine the MOF about point O

Step 3: assume tendency to rotate/ moment

Step 2: det. The line of action/ moment arm (d)

$$M_O = Fd = (60 \text{ N}) (1 \sin 45° \text{ m}) = 42.4 \text{ Nm} \quad (CCW)$$
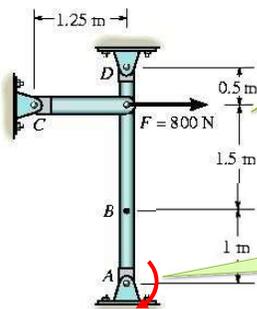
Step 2: det. The line of action/ moment arm (d)

$$M_O = Fd = (7 \text{ kN}) (4 \text{ m} - 1 \text{ m}) = 21 \text{ kNm} \quad (CW)$$

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Example 4.2

This is an example of a 2-D or coplanar force system. Determine the moments of the 800 N force acting on the frame about points **A**,B,C and D

Step 1: FBD (Sketch outline shape)

Step 2: det. The line of action/ moment arm (d)

$F = 800 \text{ N}$

Step 3: assume tendency to rotate/ moment

Step 4: use formula

$$M_A = Fd = (800 \text{ N}) (1.5 + 1 \text{ m}) = 2000 \text{ Nm} \quad (CW)$$

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Solution Example 4.2

This is an example of a 2-D or coplanar force system. Determine the moments of the 800 N force acting on the frame about points A,**B**,C and D

Step 1: FBD (Sketch outline shape)

Step 2: det. The line of action/ moment arm (d)

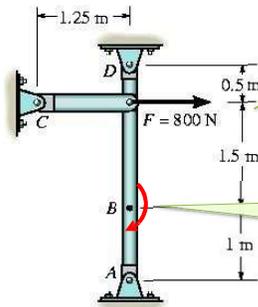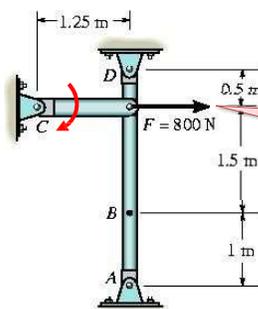Step 3: assume tendency to rotate/ moment

Step 4: use formula

$$M_B = Fd = (800\ N)\ (1.5\ m) = 1200\ Nm\quad (CW)$$

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Example 4.2

This is an example of a 2-D or coplanar force system. Determine the moments of the 800 N force acting on the frame about points A,B,**C** and D

Moment is zero

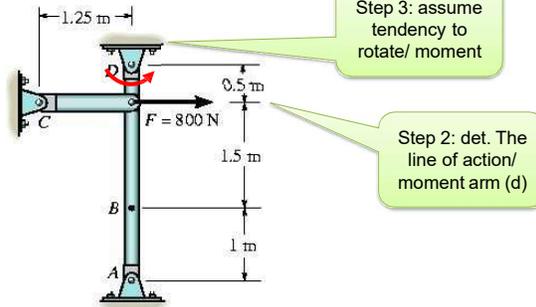Step 2: line of action F passes through C

Step 4: use formula

$$M_C = Fd = (800\ N)\ (0\ m) = 0\ Nm$$

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Solution Example 4.2

This is an example of a 2-D or coplanar force system. Determine the moments of the 800 N force acting on the frame about points A,B,C and **D**

Step 3: assume tendency to rotate/ moment

Step 2: det. The line of action/ moment arm (d)

Step 4: use formula

$$M_D = Fd = (800\ N)\ (0.5\ m) = 400\ Nm \quad (CCW)$$
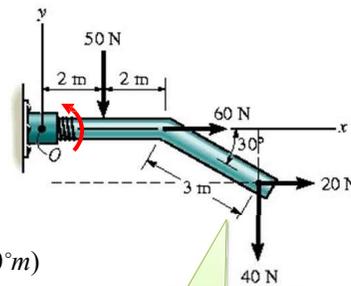
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Solution Example 4.3

This is an example of a 2-D or coplanar force system. Determine the moments of the four force acting on the rod about point O

Step 3: assume moment acts in + y direction

Step 4: use formula

$$M_{Ro} = \sum Fd$$
$$M_{Ro} = (-50N)(2m) + (60N)(0m) + (20N)(3\sin 30°m)$$
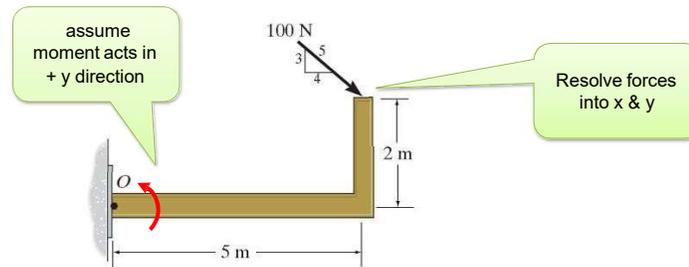$$-(40N)(4m + 3\cos 30°m)$$
$$= -334 N.m$$
$$= 334 N.m (CW)$$

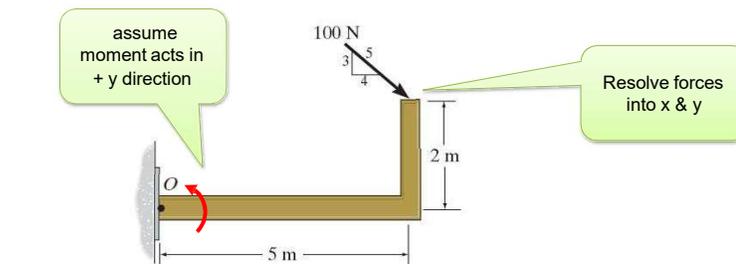Step 2: det. The line of action/ moment arm (d) for each forces

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Example 4.4

Determine the moments of the 100 N force acting on the frame about point O

Solution Example 4.4

Determine the moments of the 100 N force acting on the frame about point O

$+\uparrow F_y = \underline{-100\,(3/5)\,N}$

$+\rightarrow F_x = \underline{100\,(4/5)\,N}$

$+\ M_O = \{-100\,(3/5)N\,(5\ m) - (100)(4/5)N\,(2\ m)\}\ N{\cdot}m$

$= \underline{-460\ N{\cdot}m}$ or $\underline{460\ N{\cdot}m\ CW}$

Conclusion of The Chapter 4

- Conclusions

  - The Moment of a Force been identified
  - The Vector cross product have been implemented to solve Moment problems in Coplanar Forces Systems

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Thank you

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