University of Cihan-Sulaimaniya
Engineering Faculty
Architectural Engineering Department

ENGINEERING MECHANICS

Chapter 4: Force System Results

2nd Grade- Fall Semester 2023-2024

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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

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

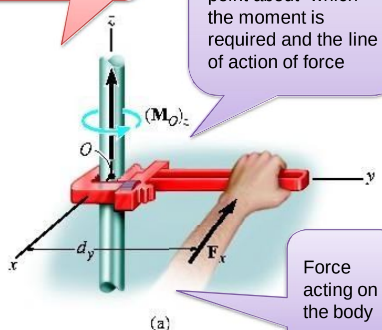
4.1 Moment of a Force

- 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

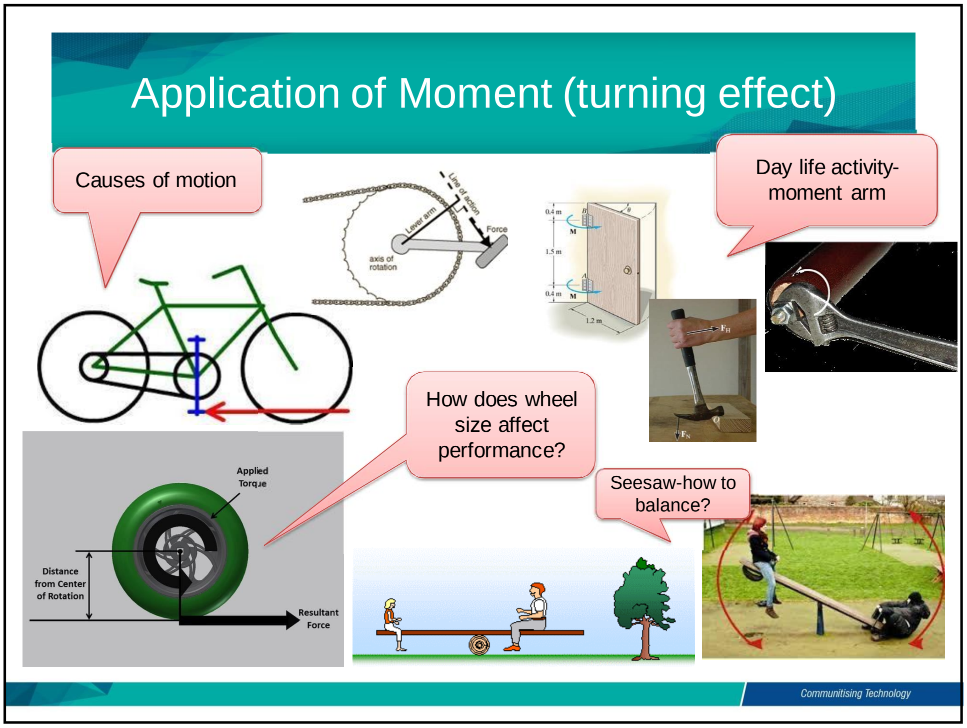
What is Moment?

Perpendicular distance between the point about which the moment is required and the line of action of force



Force acting on the body

$M_o = F d$


Application of Moment (turning effect)
Causes of motion
Day life activity- moment arm
How does wheel size affect performance?
Seesaw-how to balance?
Applied Torque
Distance from Center of Rotation
Resultant Force
axis of rotation
Force
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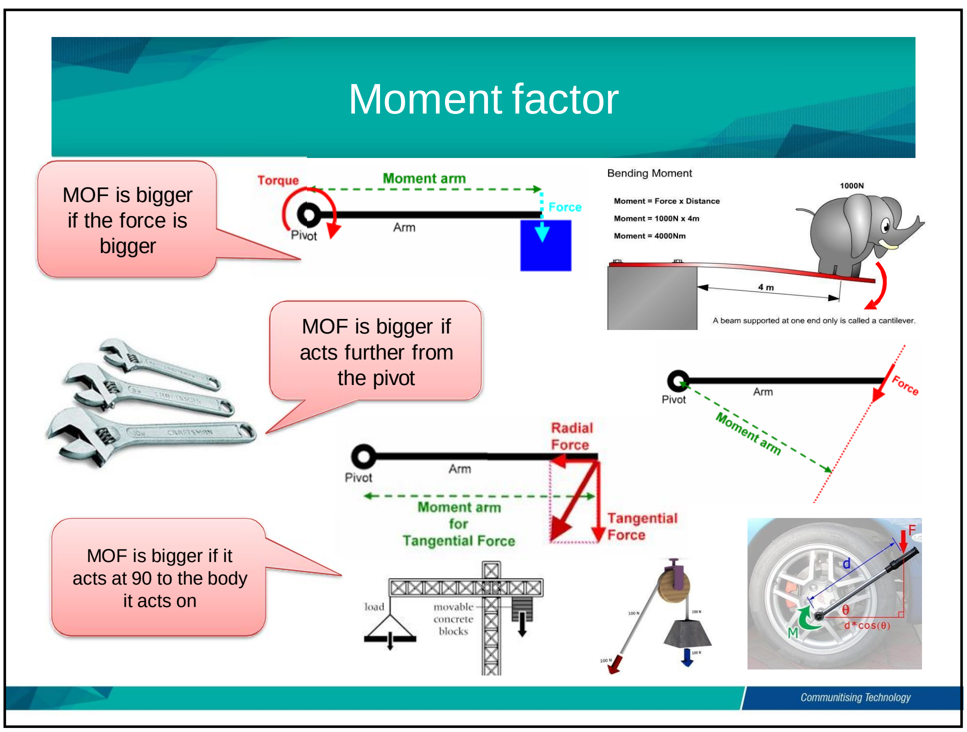
Moment factor
MOF is bigger if the force is bigger
MOF is bigger if acts further from the pivot
MOF is bigger if it acts at 90 to the body it acts on
Torque
Moment arm
Force
Pivot
Arm
Bending Moment
1000N
Moment = Force x Distance
Moment = 1000N x 4m
Moment = 4000Nm
4 m
A beam supported at one end only is called a cantilever.
Radial Force
Moment arm for Tangential Force
Tangential Force
load
movable concrete blocks
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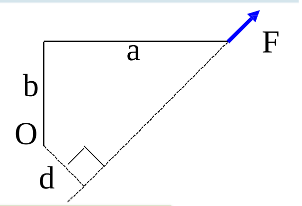
Moment of a force in 2-D (scalar formulation)

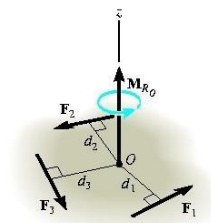
Magnitude

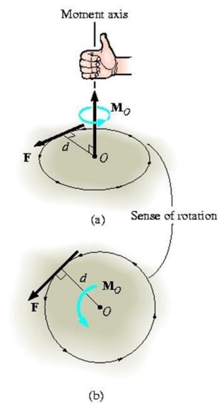
- $\mathbf{M}_O = Fd$
- d is the perpendicular distance from point O to the line of action of the force

Direction

- Direction of $\mathbf{M}_O$ 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.

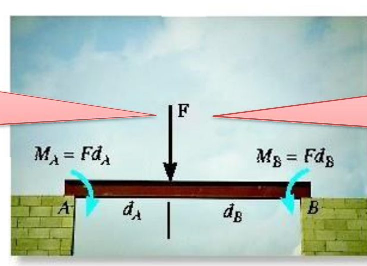
$\mathbf{M}_{Ro} = \sum Fd$

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

$M_A = F\,d_A$



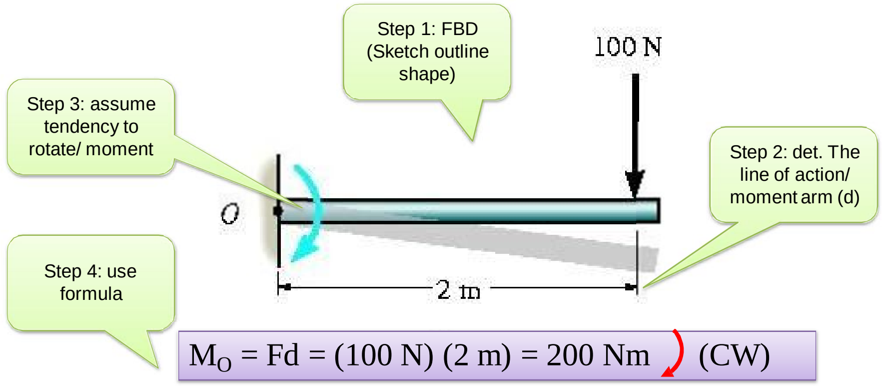
Force F tends to rotate the beam clockwise about B with moment

$M_B = F\,d_B$

Hence support at A prevents the rotation

Example 4.1

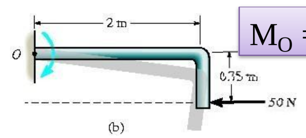
This is an example of a 2-D or coplanar force system. Determine the MOF about point O



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

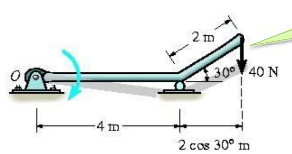
Solution Example 4.1

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



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

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

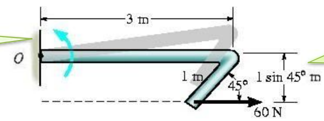


$M_O = Fd = (40\text{ N})(4\text{ m} + 2\cos 30°\text{ m}) = 229\text{ Nm}$ ↻ (CW)

Solution Example 4.1

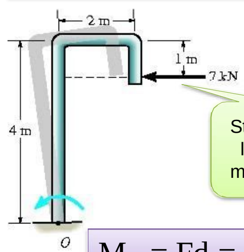
This is an example of a 2-D or coplanar force system. Determine the MOF about point O

Step 3: assume tendency to rotate/ moment



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

M_O = Fd = (60 N) (1 sin 45° m) = 42.4 Nm (CCW)



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

M_O = Fd = (7 kN) (4 m -1 m) = 21 kNm (CW)

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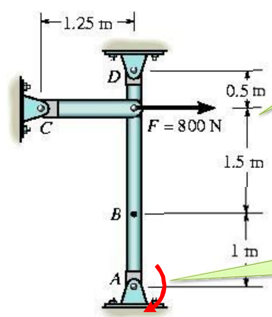
Example 4.2

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)

Step 3: assume tendency to rotate/ moment

Step 4: use formula

M_A = Fd = (800 N) (1.5 +1 m) = 2000 Nm (CW)

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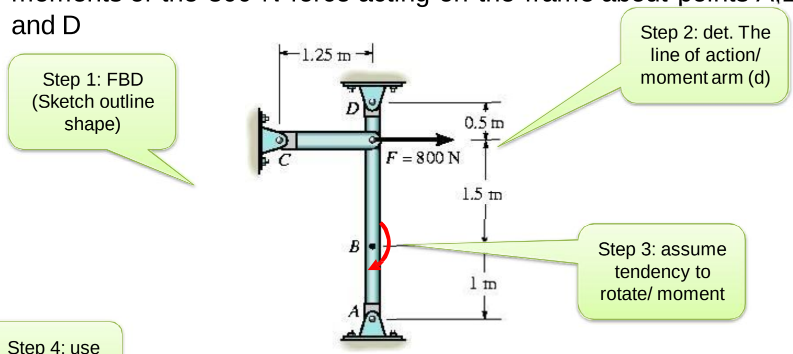
Solution Example 4.2

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

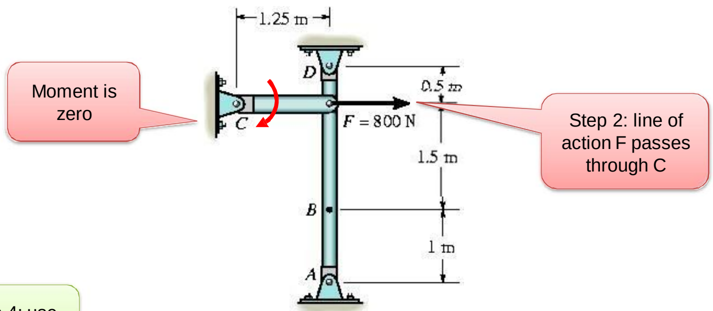


Step 4: use formula

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

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



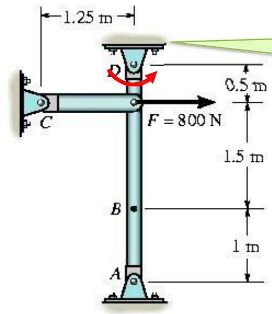
Step 4: use formula

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

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

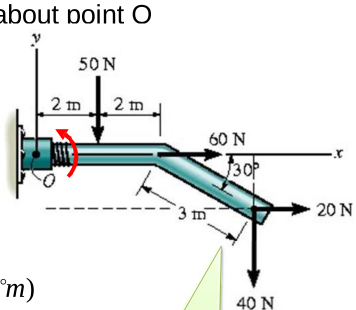
M_D = Fd = (800 N) (0.5 m) = 400 Nm (CCW)

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 4: use formula

Step 3: assume moment acts in + y direction



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

$$M_{Ro} = (-50N)(2m) + (60N)(0m) + (20N)(3\sin 30^{\circ} m)$$

$$-(40N)(4m + 3\cos 30^{\circ} m)$$

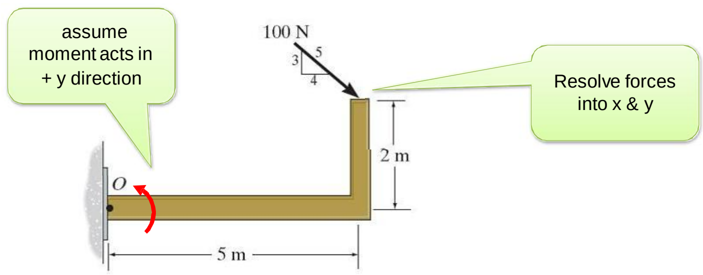
$$= -334N.m$$

$$= 334N.m(CW)$$

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

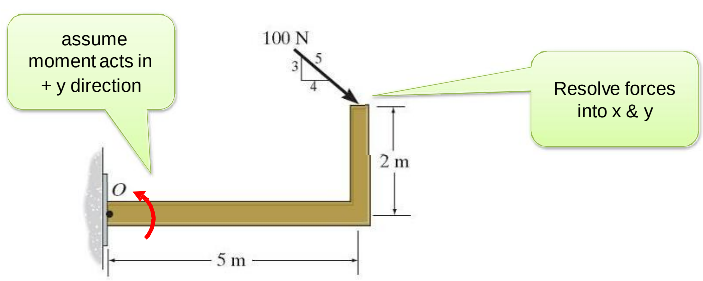
Example 4.4

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



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

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

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

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

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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