13.1 ♣ Concepts: Define and draw the moment of a force

Write the ***definition*** for the moment of force $\vec{\mathbf{F}}^Q$ applied to point Q about point O. **<u>Draw</u>** a sketch with *each* part of your definition clearly labeled.

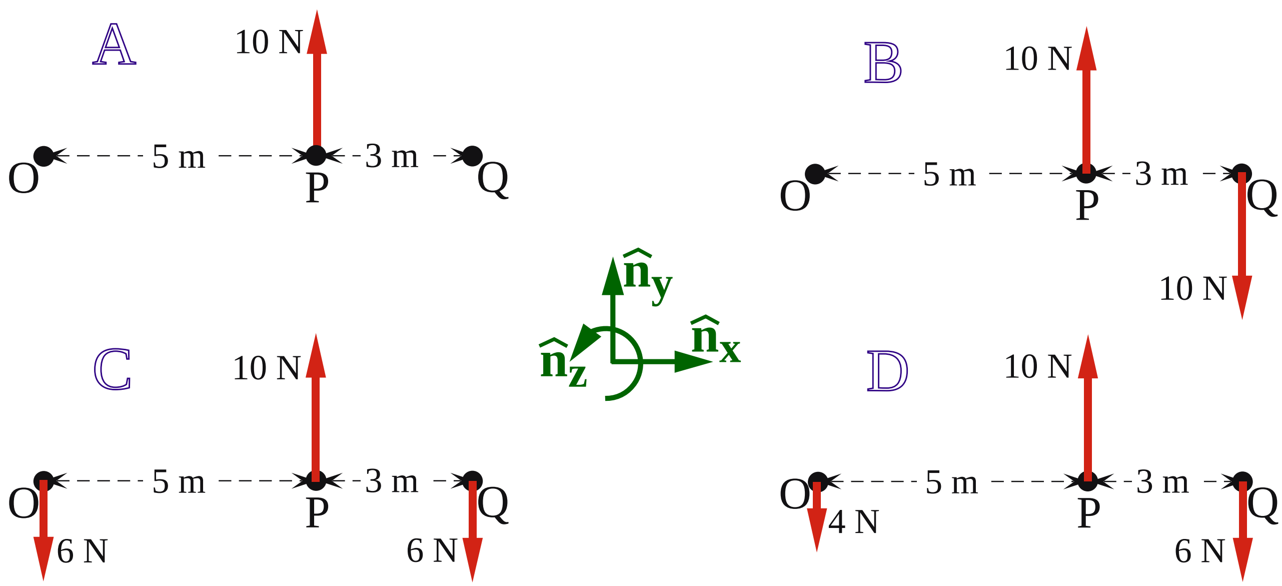
Result:

$$\vec{\mathbf{M}}^{\vec{\mathbf{F}}^Q/O} \triangleq \boxed{} \times \boxed{}$$

13.2 ♣ Moment vs. torque (refer to Section 17.5)

Consider the various sets S of forces, their resultants $\vec{\mathbf{F}}^S$, and moments about points O, P, and Q. This example shows how to easily determine whether a moment is a torque.[1]

S	$\vec{\mathbf{F}}^S$	$\vec{\mathbf{M}}^{S/O}$	$\vec{\mathbf{M}}^{S/P}$	$\vec{\mathbf{M}}^{S/Q}$	$\vec{\mathbf{M}}^{S/O} \overset{?}{=} \vec{\mathbf{M}}^{S/P} \overset{?}{=} \vec{\mathbf{M}}^{S/Q}$	Moment is torque?
A	$10\,\widehat{\mathbf{n}}_{\mathrm{y}}$	$50\,\widehat{\mathbf{n}}_{\mathrm{z}}$	$\vec{\mathbf{0}}$		**Yes/No**	**Yes/No**
B					**Yes/No**	**Yes/No**
C					**Yes/No**	**Yes/No**
D					**Yes/No**	**Yes/No**



13.3 ♣ Moment and torque concepts

75% All torques are moments. **True/False**

61% All moments are torques. **True/False**

61% The moment of a couple about a point O is equal to the moment of the couple about any other point P **True/False**

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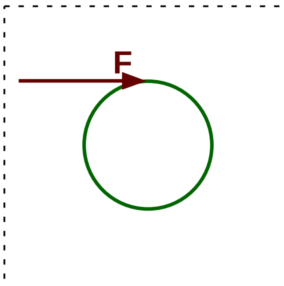
[1] Since $\boxed{\vec{\mathbf{T}}^S \triangleq \vec{\mathbf{M}}^{S/O} \text{ if } \vec{\mathbf{F}}^S = \vec{\mathbf{0}} \text{ (point } O \text{ is } \textit{any} \text{ point)}}$, the ***moment*** is a ***torque*** if $\vec{\mathbf{F}}^S = \vec{\mathbf{0}}$ (it is that simple).

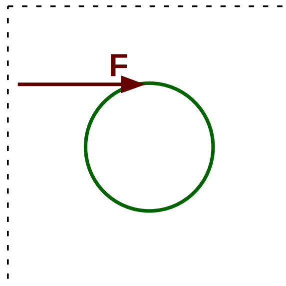
13.4 ♣ Drawing couples

Each figure below shows a single force $\vec{\mathbf{F}}$ applied tangentially to a point on the periphery of a circle. Complete each figure by drawing couples consisting of **2**, **3**, and **4** forces, respectively, so:

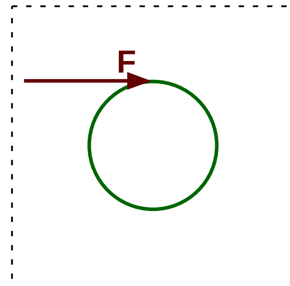
- Each force has magnitude $|\vec{\mathbf{F}}|$ and is applied at distinct points on the circle's periphery
- Each force is directed **tangent** to the circle's periphery
- The set of forces create a couple with non-zero torque



Couple with two forces



Couple with three forces

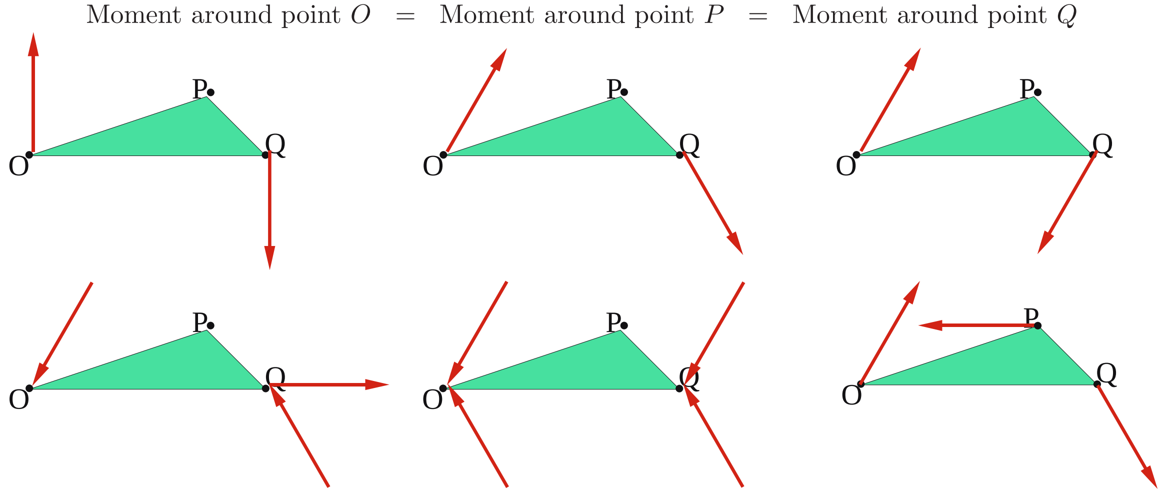


Couple with four forces

13.5 ♣ Moments of forces about various points

Consider the six figures below, each which contain a set of forces. Circle the figure(s) in which the moment of its set of forces about points O, P, and Q all are equal, i.e.,

$$\text{Moment around point } O \; = \; \text{Moment around point } P \; = \; \text{Moment around point } Q$$



Note: All forces have the same magnitude. Forces that are not horizontal or vertical are 30° from vertical.

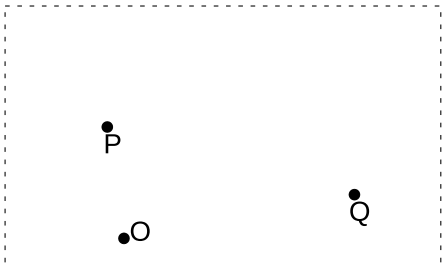
13.6 ♣ Forces, moments, and lines of action

Draw a non-zero force $\vec{\mathbf{F}}^P$ on point P and a non-zero force $\vec{\mathbf{F}}^Q$ on point Q so:

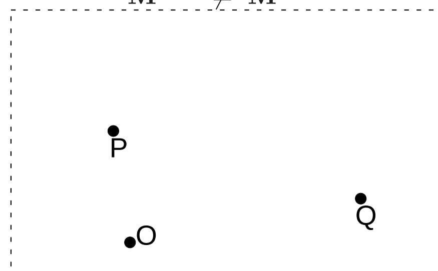
- $\vec{\mathbf{F}}^P = \vec{\mathbf{F}}^Q$ (force on P has the same magnitude and direction as the force on Q)
- $\vec{\mathbf{M}}^{\vec{\mathbf{F}}^P/O}$ (moment of $\vec{\mathbf{F}}^P$ about point O) is **equal** to $\vec{\mathbf{M}}^{\vec{\mathbf{F}}^Q/O}$ (moment of $\vec{\mathbf{F}}^Q$ about O).

Repeat on the right-figure below, except ensure $\vec{\mathbf{F}}^P$ and $\vec{\mathbf{F}}^Q$ produce **unequal** moments about O.

$\vec{\mathbf{M}}^{\vec{\mathbf{F}}^P/O} = \vec{\mathbf{M}}^{\vec{\mathbf{F}}^Q/O}$

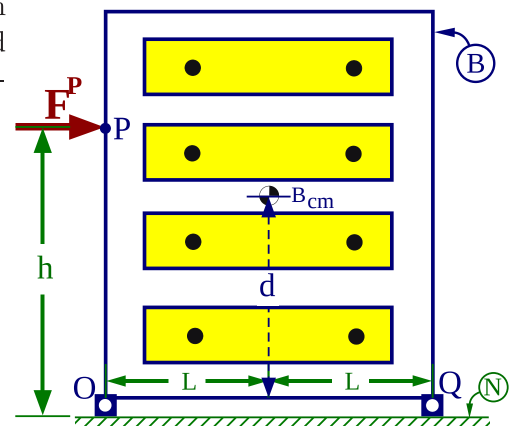


$\vec{\mathbf{M}}^{\vec{\mathbf{F}}^P/O} \neq \vec{\mathbf{M}}^{\vec{\mathbf{F}}^Q/O}$



13.7 FE/EIT Review – Bureau tipping and static friction.

The figure to the right shows a rigid uniform-density bureau B in contact with a **rough** flat horizontal surface N at points O and Q of B. A person (not shown) is pushing the bureau horizontally-right with a force of measure F^P applied to point P of B.



Related: Hw 13.8

Description	Symbol
Mass of bureau	m
Earth's gravitational acceleration	g
Half-width of bureau	L
Distance between points O and P	h
Distance between B_{cm} and line $\overline{OQ}$	d
Measure of normal force on P from person	F^P
Measure of normal force on O from inclined plane	F_y^O
Measure of normal force on Q from inclined plane	F_y^Q

Regard this system as planar and in ***static equilibrium***.

This question investigates the role of ***static friction*** on bureau tipping. Answer the following questions in terms of symbols in the table and μ_s (the ***coefficient of static friction*** between B and N).

- **Before forming any equations**, **draw** a ***free-body diagram (FBD)*** of B and use your intuition (guess) whether or not the **start** of the bureau tipping depends on (circle all that apply).

  $h \quad L \quad d \quad m \quad g \quad \mu_s$

- One way for the bureau to start tipping is for it to lose contact with N at point O. At this instant, the normal and friction forces at O are $\vec{\mathbf{0}}$ [N can push upward (not pull downward) on B]. In this context, determine the minimum value of F^P to tip B clockwise. Next, determine h_{slide}, the maximum height where a sufficient push makes the bureau **start** to slide (not tip).

  Result: **Tip minimum push:** $F^P_{\text{minimum}} = \frac{\square}{\square}$ **Slide max height:** $h_{\text{slide}} = \frac{\square}{\square}$

- When $\mu_s \approx 0$, h_{slide} is **much smaller/smaller/equal to/larger/much larger** than L.
- In view of this **static analysis**, the **start** of bureau tipping depends on (circle all that apply)

  $h \quad L \quad d \quad m \quad g \quad \mu_s$