# GNG 1105E – Engineering Mechanics

## CHAPTER S2 – FORCE SYSTEMS

# Assigned readings (S2B)

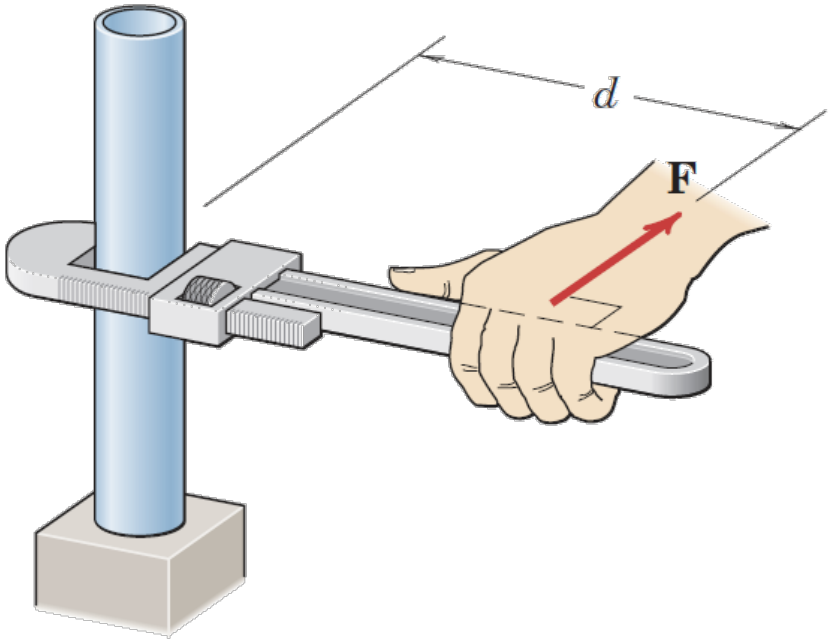
2/4 Moment

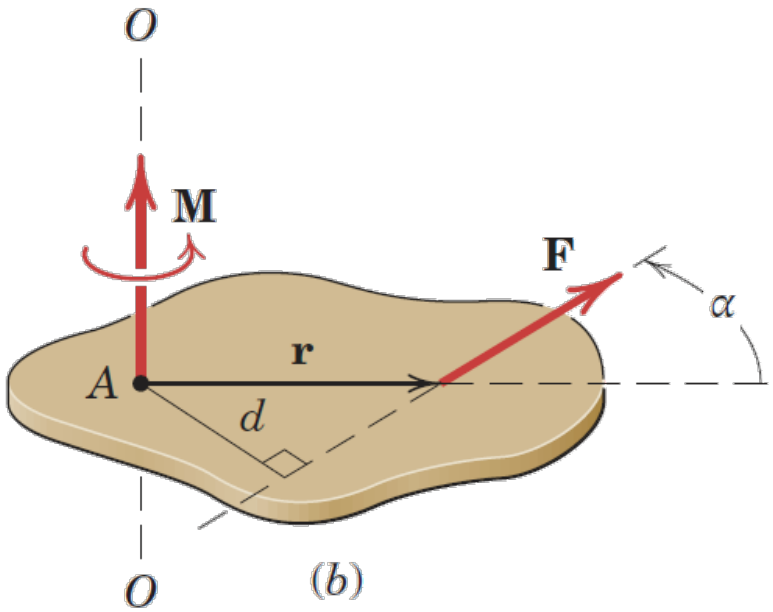
2/5 Couple

2/6 Resultants

# 2/4 Moment

A **moment** is a tendency of a force to rotate a body about an axis

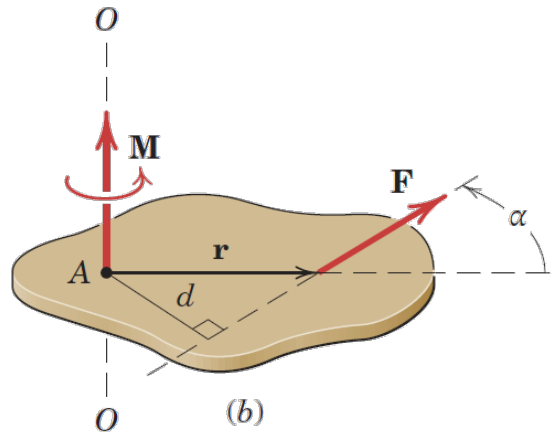


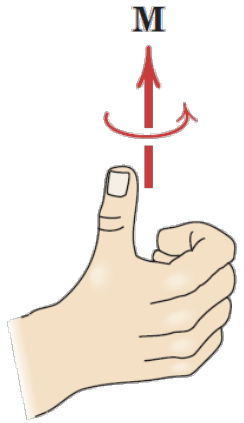



# 2/4 Moment

The **right-hand rule**:

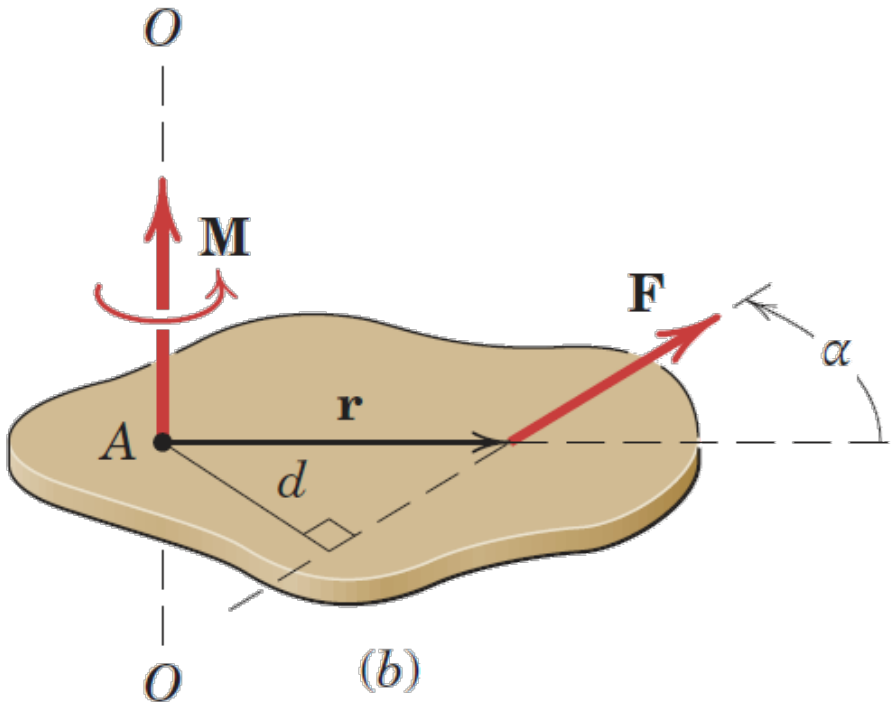
1. Position your right hand such that your fingers point in the same direction as the force.
2. Orient your hand such that the point you are computing the moment about is on the same side as your palm. From the figure at right, your hand is positioned such that the moment arm *d* intersects the middle of your palm.
3. Close your fingers to make a fist and extend your thumb straight up. From the figure at right, imagine closing your fist around line *O*-*O*, and your thumb would point in the direction of the moment vector. Curling your fingers about this line would represent the rotation of the moment about the axis.

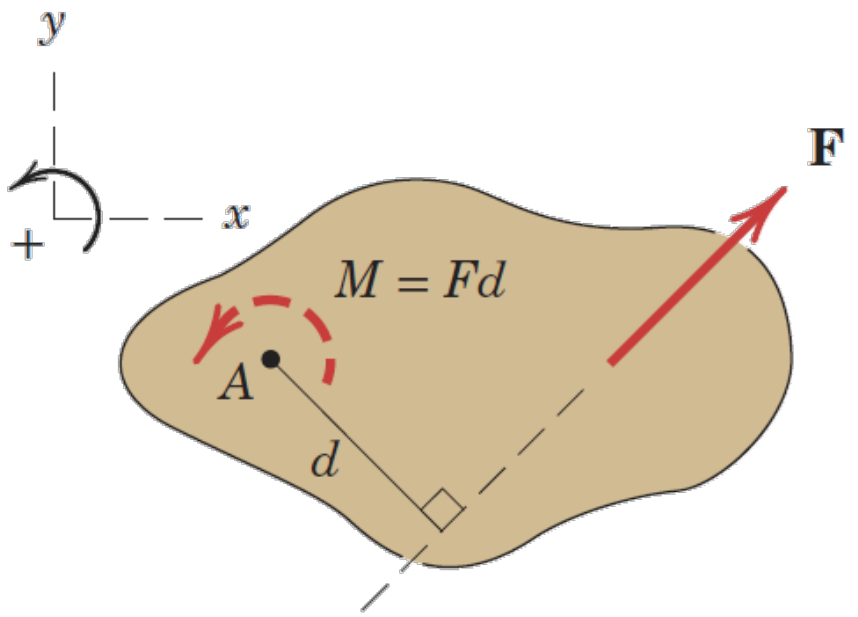


# 2/4 Moment

For 2-dimensional problems, a simpler representation can be used

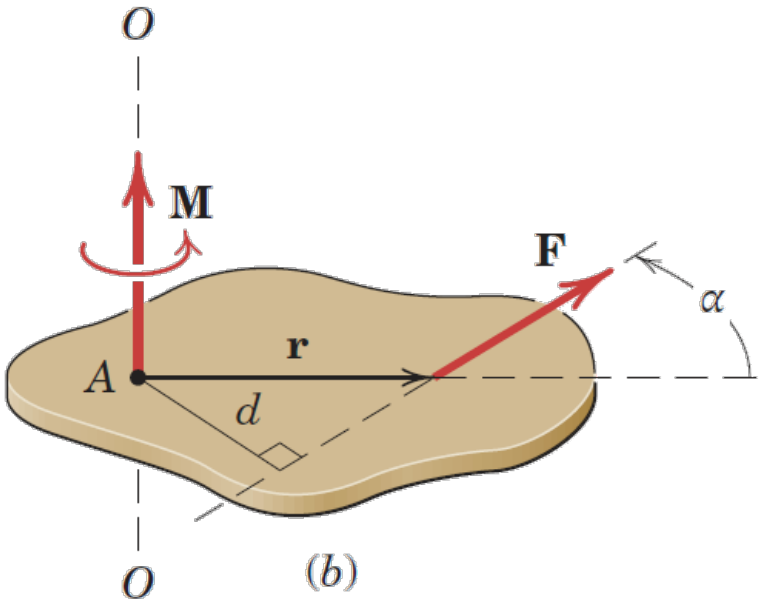


# 2/4 Moment

Scalar development:

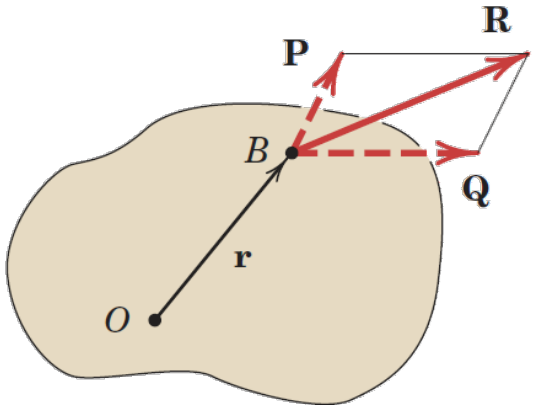
Vector development:



# 2/4 Moment

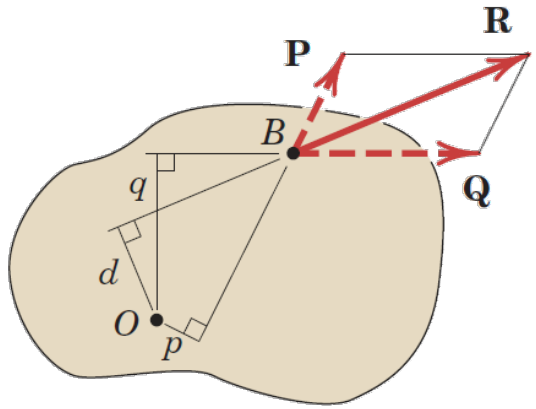
## Varignon's Theorem

The moment of a force about any point is equal to the sum of the moments of the components of the force about the same point.




$$\mathbf{R} = \mathbf{P} + \mathbf{Q}$$

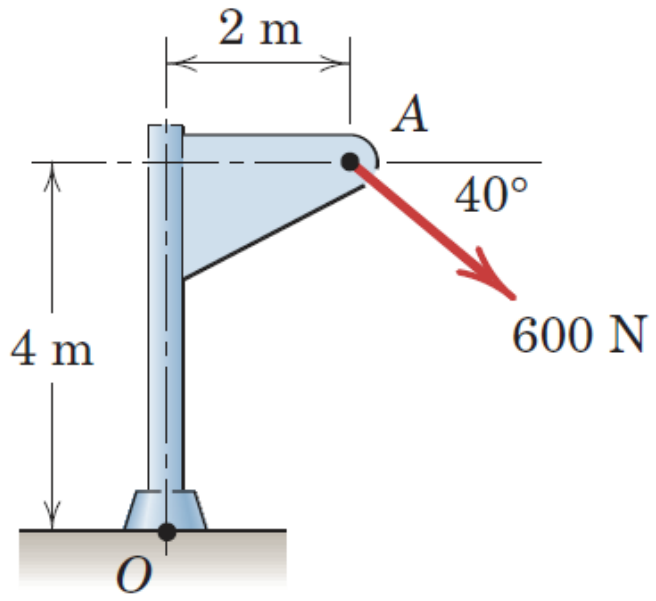
$$\mathbf{M}_o = \mathbf{r} \times \mathbf{R} = \mathbf{r} \times (\mathbf{P} + \mathbf{Q}) = \mathbf{r} \times \mathbf{P} + \mathbf{r} \times \mathbf{Q}$$



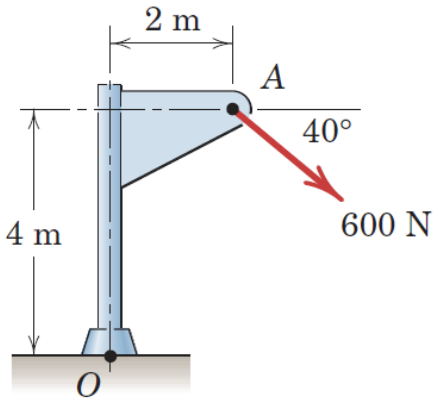

$$M_o = Rd = -pP + qQ$$

# Sample problem 2/5

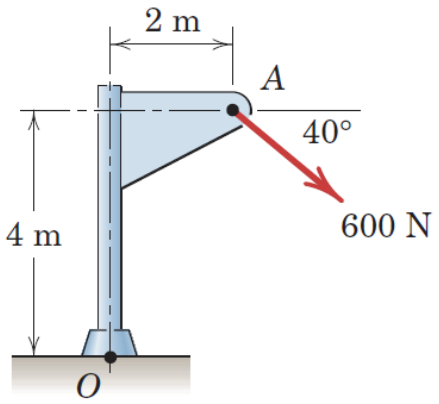
Calculate the magnitude of the moment about the base point *O* of the 600-N force.



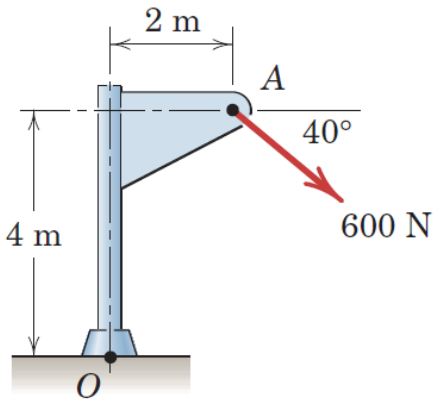
# Sample problem 2/5



# Sample problem 2/5



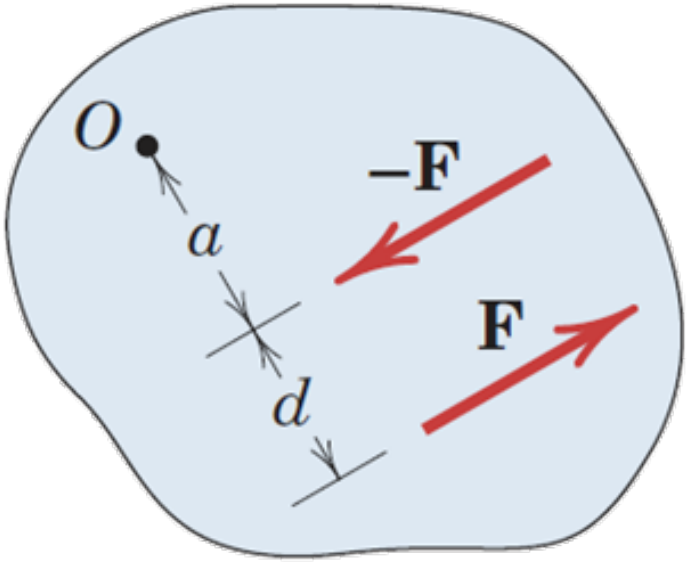
# Sample problem 2/5



# 2/5 Couple

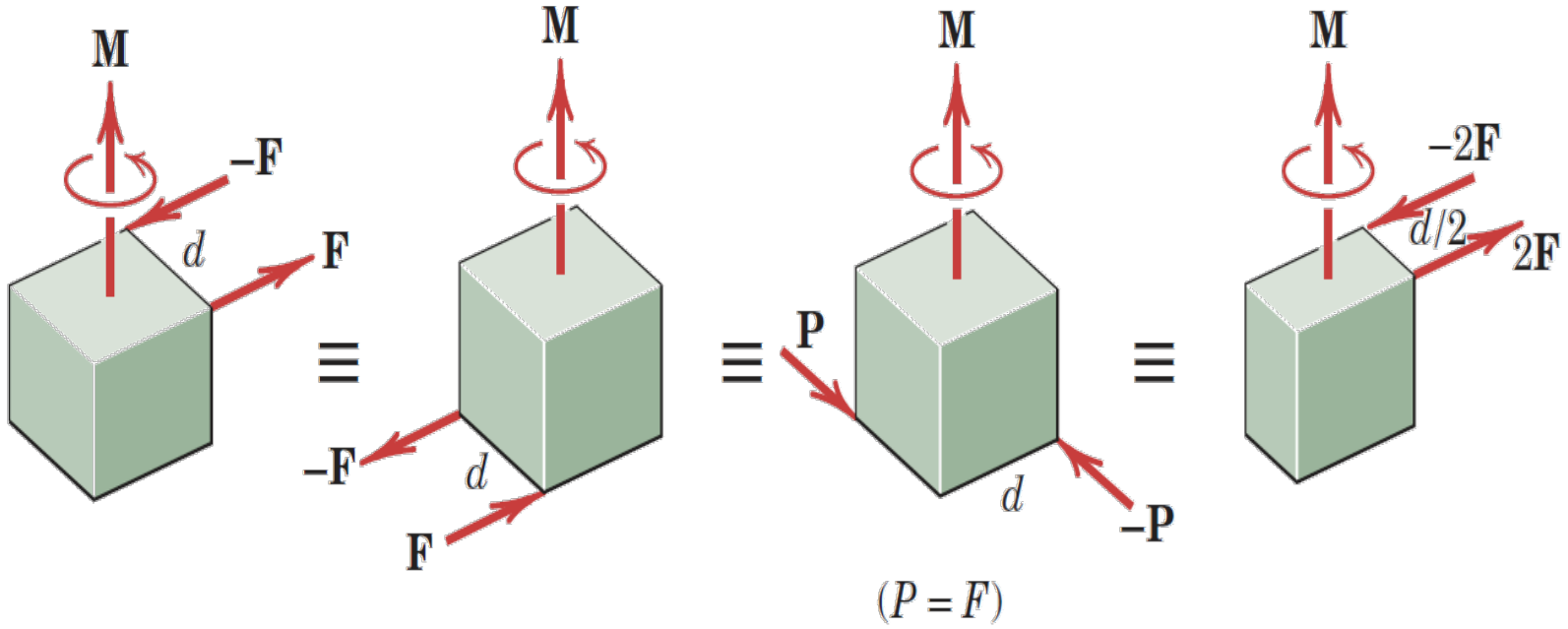
A **couple** is a moment produced by two equal, opposite, and non-collinear forces

A couple is a **free vector**



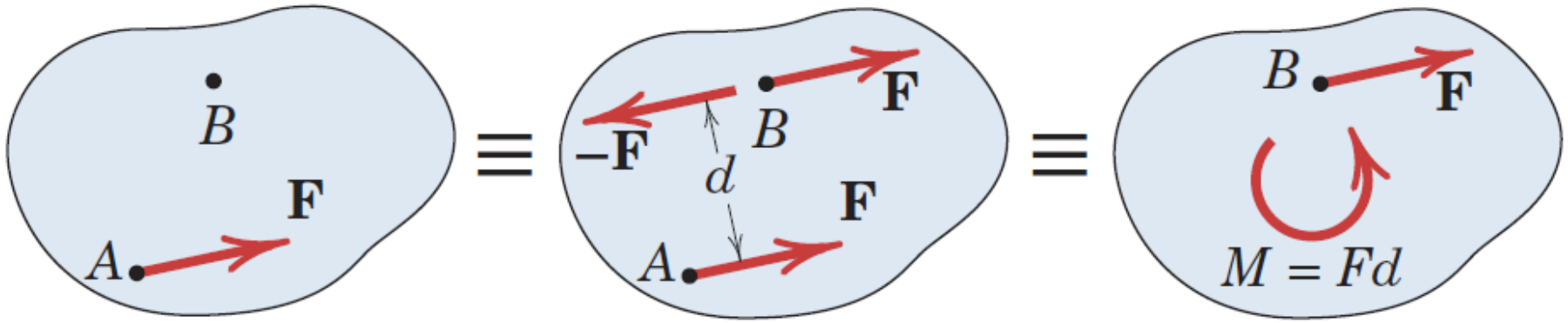
# 2/5 Couple

The actual magnitude and direction of the forces producing a couple are not relevant



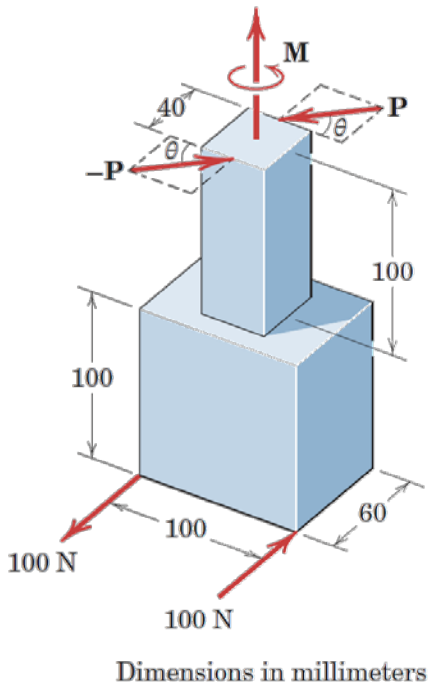
# 2/5 Couple

Any force acting at a particular location on a body can be replaced by an **equivalent force** acting at a different location **and a couple**

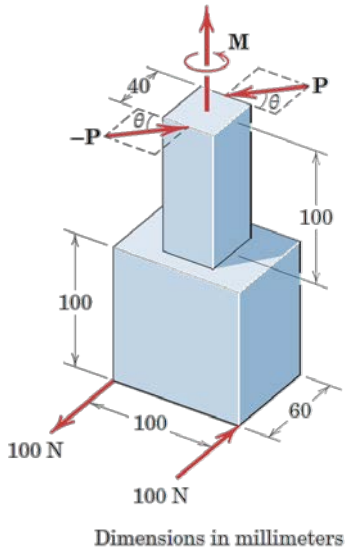


# Sample problem 2/7

The rigid structural member is subjected to a couple consisting of the two 100-N forces. Replace this couple by an equivalent couple consisting of the two forces **P** and **−P**, each of which has a magnitude of 400 N. Determine the proper angle $\theta$.



# Sample problem 2/7

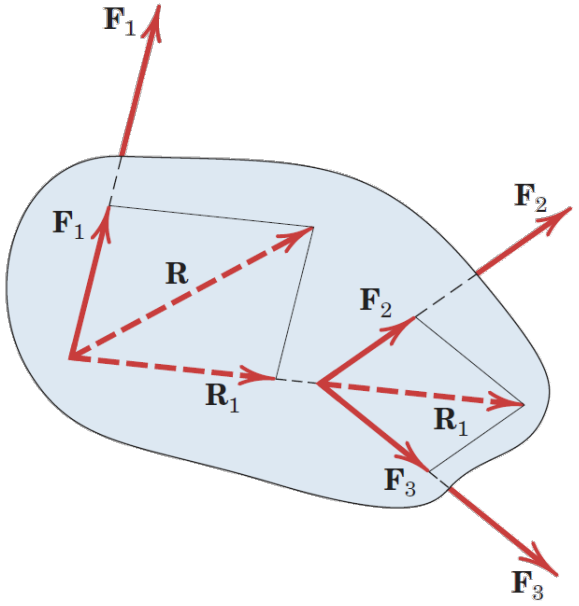


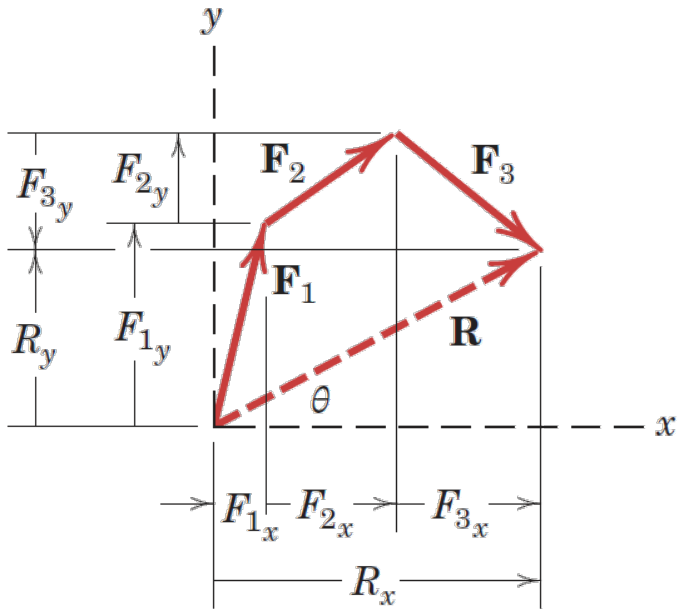
Dimensions in millimeters

# 2/6 Resultants

The **resultant** of a system of forces is the simplest force combination which can replace the original forces to produce the **same effect** on the rigid body

When the resultant is equal to zero, the body is in **equilibrium**

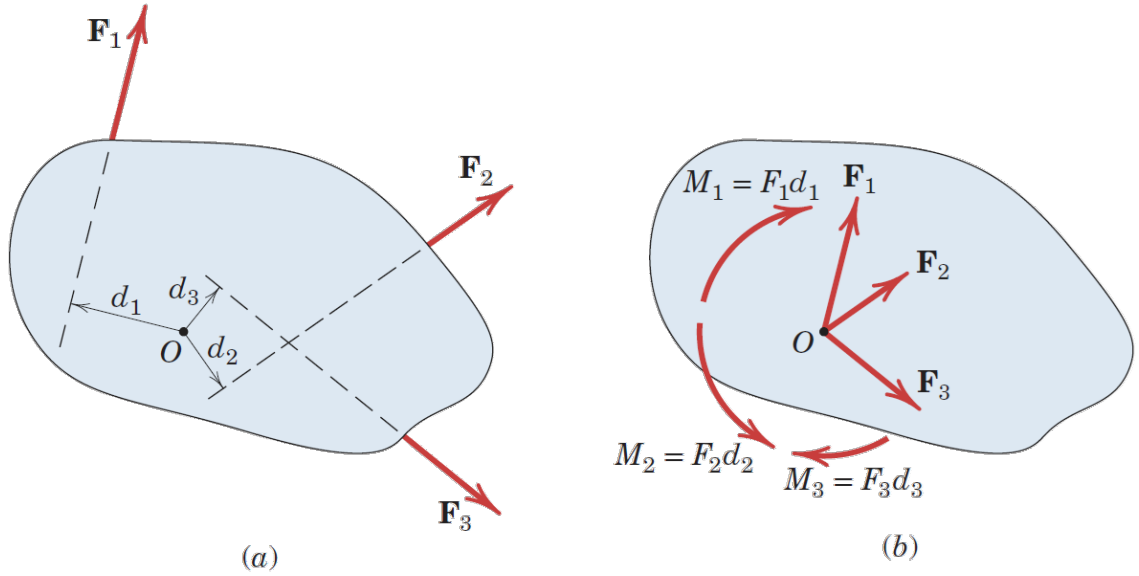


# 2/6 Resultants

Finding the resultant and its line of action:

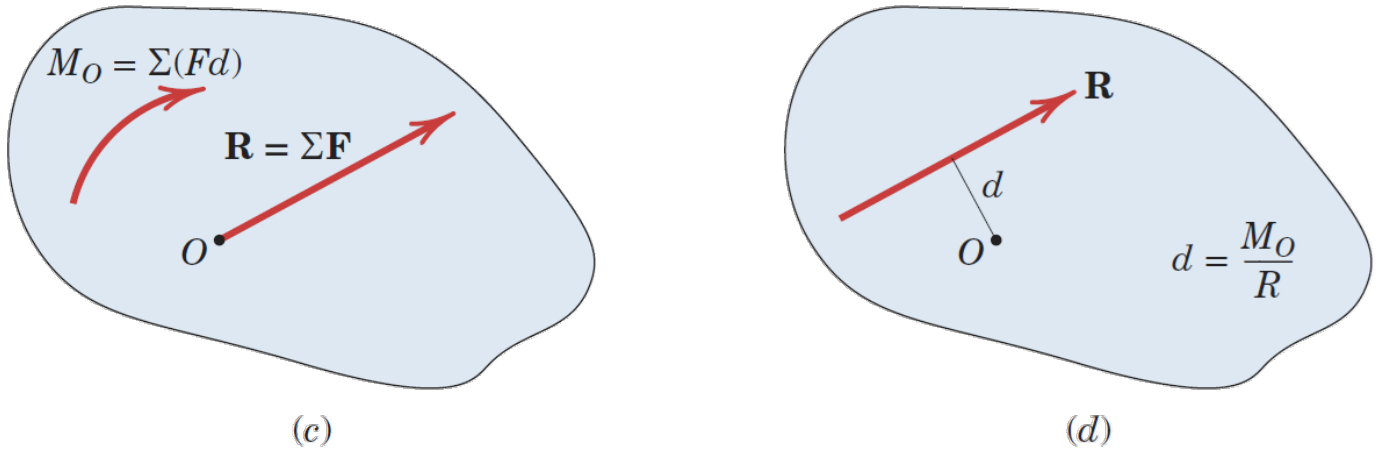
1. Move all the forces to a convenient reference point. Remember to include a couple for each force to ensure that the net tendency to **translate** and **rotate** is equivalent



# 2/6 Resultants

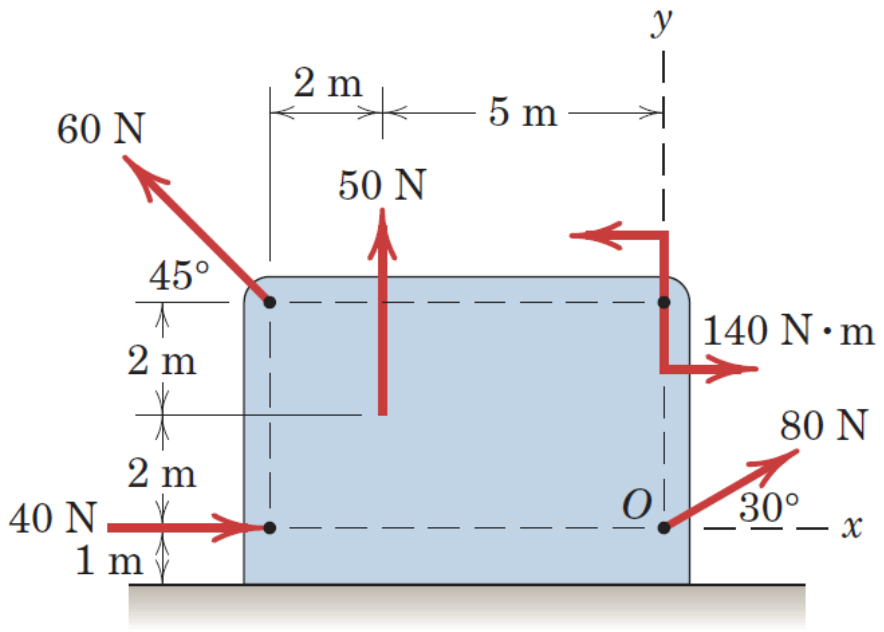
2. Add all the forces to find the **resultant force**, and add all couples to find the **resultant couple**. This will reduce the system of forces to an **equivalent force-couple system**

3. Find the line of action of the single force that produces the same moment about point O.

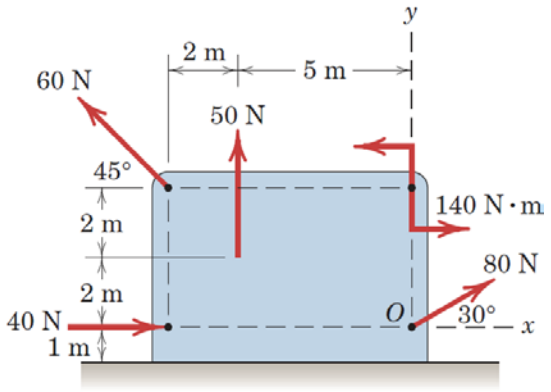


# Sample problem 2/9

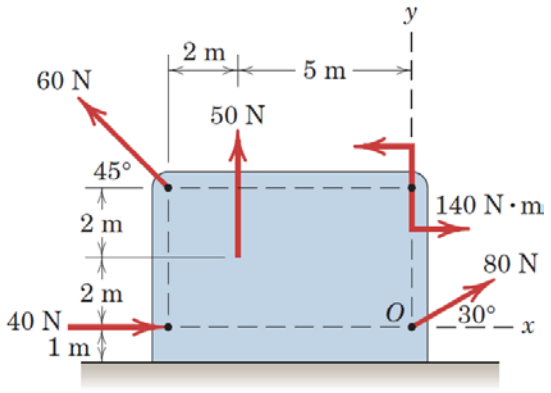
Determine the resultant of the four forces and one couple which act on the plate shown.



# Sample problem 2/9



# Sample problem 2/9



# Sample problem 2/9