

Static Equilibrium



Equilibrium implies that the object moves with both constant velocity and constant angular velocity.



Will deal now with the special case in which both of these velocities are equal to zero.

This is called **static equilibrium**.



Static equilibrium is a common situation in engineering.

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Conditions for Equilibrium



- The net external force on the object must equal zero.

$$\sum \vec{F}_{ext} = 0$$

- If the object is modeled as a particle, then this is the only condition that must be satisfied.
- The net external torque on the object about any axis must be zero.

$$\sum \vec{\tau}_{ext} = 0$$

- This is needed if the object cannot be modeled as a particle.
- These conditions describe the **rigid object in equilibrium**.

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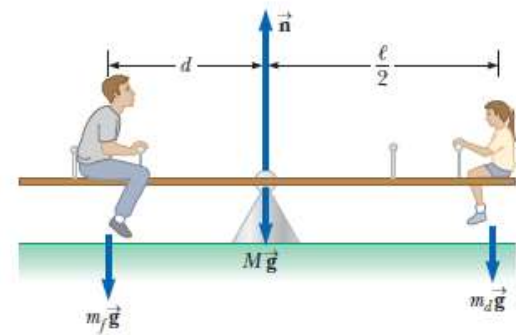
The Seesaw

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- ☒ R. A. Serway and J. W. Jewett, Jr., *Physics for Scientists and Engineers*, 9th Ed., CENGAGE Learning, 2014.
- ☐ J. Walker, D. Halliday and R. Resnick, *Fundamentals of Physics*, 10th ed., WILEY, 2014.
- ☐ H. D. Young and R. A. Freedman, *University Physics with Modern Physics*, 14th ed., PEARSON, 2016.
- ☐ H. A. Radi and J. O. Rasmussen, *Principles of Physics For Scientists and Engineers*, 1st ed., SPRINGER, 2013.

A seesaw consisting of a uniform board of mass M and length ℓ , supports at rest a father and daughter with masses m_f and m_d , respectively, as shown. The support (called the fulcrum) is under the center of mass of the board, the father is a distance d from the center, and the daughter is a distance $\ell/2$ from the center.



- Determine the magnitude of the upward force $\vec{n}$ exerted by the support on the board.
- Determine where the father should sit to balance the system at rest.

$$n - m_f g - m_d g - Mg = 0$$

$$(1) \quad n = m_f g + m_d g + Mg = (m_f + m_d + M)g$$

$$(m_f g)(d) - (m_d g)\frac{\ell}{2} = 0$$

$$d = \left(\frac{m_d}{m_f}\right)\frac{\ell}{2}$$