

Chapter 2 Mechanical Equilibrium

Summary

THE BIG IDEA : An object in mechanical equilibrium is stable, without changes in motion.

2.1 Force

✓ A force is needed to change an object's state of motion.

- A **force** is a push or a pull. A force is always required to change an object's state of motion.
- The combination of all forces acting on an object is called the **net force**. The net force on an object changes its motion.
- When you hold a rock at rest in your hand, you are pushing upward on it with as much force as Earth's gravity pulls down on it. The net force on the rock is zero.
- The scientific unit of force is the newton, abbreviated N.
- Tension is a "stretching force."
- Weight is the force of gravity acting downward on an object.
- A **vector** is an arrow that represents the magnitude and direction of a quantity. A **vector quantity** is a quantity that needs both magnitude and direction for a complete description. Force is an example of a vector quantity.
- A **scalar quantity** is a quantity that can be described by magnitude only and has no direction. Time, area, and volume are scalar quantities.

2.2 Mechanical Equilibrium

✓ You can express the equilibrium rule mathematically as $\sum F = 0$.

- **Mechanical equilibrium** is a state wherein no physical changes occur; it is a state of steadiness.
- Whenever the net force on an object is zero ($\sum F = 0$), the object is said to be in mechanical equilibrium—this is known as the **equilibrium rule**. The symbol \sum stands for "the sum of" and F stands for "forces."
- For a suspended object at rest, the forces acting upward on the object must be balanced by other forces acting downward to make the vector sum equal zero.

2.3 Support Force

✓ For an object at rest on a horizontal surface, the support force must equal the object's weight.

- A **support force** is the upward force that balances the weight of an object on a surface. A support force is often called the *normal force*.
- An upward support force is positive and a downward weight is negative.
- The weight of a book sitting on a table is a negative force that squeezes downward on the atoms of the table. The atoms squeeze upward on the book. The compressed atoms produce the positive support force.

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2.4 Equilibrium for Moving Objects

- ✓ Objects at rest are said to be in static equilibrium; objects moving at constant speed in a straight-line path are said to be in dynamic equilibrium.
- Equilibrium is a state of no change. An object under the influence of only one force cannot be in equilibrium. Only when there is no force at all, or when two or more forces combine to zero, can an object be in equilibrium.
- Both static equilibrium and dynamic equilibrium are examples of mechanical equilibrium.

2.5 Vectors

- ✓ **The Parallelogram Rule:** To find the resultant of two nonparallel vectors, construct a parallelogram wherein the two vectors are adjacent sides. The diagonal of the parallelogram shows the resultant.
- The sum of two or more vectors is called their **resultant**.
- Combining vectors is simple when they are parallel. If they are in the same direction, they add. If they are in opposite directions, they subtract. To find the resultant of nonparallel vectors, use the parallelogram rule.
- When applying the parallelogram rule to two perpendicular vectors that are equal in magnitude, the parallelogram is a square. The resultant is $\sqrt{2}$, or 1.414, times one of the vectors.
- When an object is suspended at rest from two non-vertical ropes, there are three forces acting on it: a tension in the left rope, a tension in the right rope, and the object's weight. The resultant of rope tensions must have the same magnitude as the object's weight.