8 | Newton's Third Law of Motion

8.0 Chapter Preview

In this chapter, we will:

- Introduce Newton's 3rd law of motion—when object 1 exerts a force on object 2, object 2 exerts an equal and opposite force upon object 1. These "paired forces" are known as 3rd law force pairs.
- Learn how to properly identify 3rd law force pairs.
- Study force systems and force interactions relative to the 3rd law.
- Reveal how objects move in a world of "equal and opposite forces."

8.1 INTRODUCTION

• "When one object exerts a force on a second object, the second object exerts an equal force in the opposite direction on the first object."

Topic question:

What are paired forces called that exist due to Newton's 3rd law? **3rd law force pairs.**

8.2 SYSTEMS AND THE THIRD LAW OF MOTION

• A force system is defined by all the forces acting on the all the objects present in a force study.

Topic question:

True or False? If one object exerts a force on another object, then there will be a 3rd law force interaction present between the 2 objects. **True**

8.3 THE IMPORTANCE OF GRAVITY AND FORCE INTERACTIONS WITHIN A FORCE SYSTEM

• A detailed discussion of gravity's role in determining correct 3rd law force pair interactions, which boils down to ensuring that the force of earth's gravity on an object is paired with the force of the object's gravity on the earth.

Topic question:

A meteorite is falling through the sky on its way to landing on the ground. It falls to earth, of course, because of the force of earth's gravity on the meteor. What is the appropriate 3rd law force pair in that force interaction? **The force of the meteorite's gravity pull on the earth.**

8.4 DEFINING THE LABELS REALLY HELPS

• The importance of clearly defining the forces because it helps to ensure appropriate 3rd law force pairing is detailed.

No topic question.

8.5 NEWTON'S 3RD LAW AND MOTION

- Whether objects are in motion or motionless, these three rules can help properly identify 3rd law force pairs:
 - The forces must be in opposite directions.
 - The forces must act on different objects.
 - The forces must be the same kind of force.

Topic question:

Why is earth gravitational force pulling down on a mailbox and the normal force of the earth pushing up on the mailbox not appropriate 3rd law force pairs? Because the forces both act on the same object (the mailbox) and they are not the same kind of force (gravity is a noncontact force and the normal force is a contact force).

8.6 FORCE SYSTEMS WITH MULTIPLE FORCES

• A detailed examination of the force interactions in a multi-force system is discussed.

No topic questions.

8.7 IF THE FORCES IN A FORCE SYSTEM ARE ALL EQUAL AND OPPOSITE, HOW DOES ANYTHING EVER MOVE?

• The boat's propeller pushing backwards on the water and the water pushing forwards on the boat propeller explains how the boat maintain dynamic equilibrium.

No topic questions.

8.8 EXPANDING THE PRACTICAL ASPECTS OF THE 3RD LAW

• Motion is explained by the force of one object pushing against another object and the other object pushing back against the first object, causing one (or both) of the objects involved in the force interaction to move.

Topic question:

Describe how a jet engine makes an airplane move through the air. There is a fan inside of a jet engine, and the fan blades spin around. As they spin, the surface of the fan blades push backwards on the air and the air pushes forwards on the fan blades. As the blades spin faster, the force they exert on the air increases; therefore increasing the force the air pushed forwards on the fan blades. Eventually, the air is pushing forward on the fan blades with enough force that the plane's inertia is overcome and it starts moving.

8.10 KEY CHAPTER POINTS

- Newton's 3rd law of motion states that when object 1 exerts a force on object 2, object 2 exerts an equal and opposite force back upon object 1.
- Newton's 3rd law relies on appropriate force pairs to exert the equal and opposite forces. The following "rules" are applied to determine force pairs:
 - The two forces must be in opposite directions.
 - The two forces must act on different objects.
 - The two forces must be the same type of force.
- A force system exists when two or more forces are acting upon one or more objects in an environment of study.
- A force interaction exists when one object exerts a force on another object.
 - Care must be taken to properly identify if the two forces are force pairs.
- Gravity force pairs can be confusing, but if you remember to always pair the force of earth's gravity pull for an object with the force of the object's gravity pull for the earth, confusion is removed.
- Taking care to assess which objects exert force upon one another and meticulously labeling forces in the free body diagram help to properly identify paired forces.
- In a 3rd law world where force pairs "cancel each other out," motion occurs when there is a net force in the direction of movement.