Physics Chapter 6 and 7 Study Guide Key

# Chapter 6: Newton’s Second Law: F = ma

# Prerequisite Knowledge and Essential Facts

\* Equilibrium is achieved when forces are balanced. In other words, the NET force is zero. When this occurs, an object will not accelerate – that is, its velocity will remain the same. If you see “constant velocity” or something like that in a question, you know that there is no acceleration and zero NET force.

\* Weight: The name given to the force of gravity on a massive object. w = mg

\* The acceleration due to gravity on an object is not affected by the object’s velocity.

\* Accelerations are produced by NET forces. Where there is no NET force, there is no acceleration.

\* Free-fall is acceleration due to gravity without air resistance.

# Prerequisite Knowledge and Essential Facts - Questions

When an object is in equilibrium, the **net force** is zero, therefore there is no **acceleration**.

The force of gravity on an object is called the object’s **weight**.

Acceleration is produced by a **net force**.

If an object is thrown downward at 14.3 m/s (near the surface of the Earth), what is the acceleration of the object? **Ans: 10 m/s2 – this is always the acceleration due to gravity. The initial velocity is irrelevant.**

# The Force of Gravity

Gravity always points straight down toward the center of the Earth. The weight of an object is a measure of the force of gravity on that object. Remember that weight is different from mass.

w = mg

f = ma

It is not a coincidence that these formulas are similar. The weight equation is just a specific form of Newton’s equation.

It is essential to understand that as the mass of an object increases, so does the force of gravity on that object. The ratio of F/m is always constant and equal to g. This is why all objects fall at the same rate in a vacuum.

# The Force of Gravity – Questions

A safe weighs 1600 N. The force of gravity on the safe is **1600** N. (**By definition)**

A 1-kg rock is thrown vertically into the air. The net force on the rock at the peak of its flight is **10 N**. (**F = ma = 1 \* 10 = 10 N)**

An object weighs 145 N. The force of gravity on the object while in free-fall is **145 N**.

A book weighs 162 N on the Moon, where the acceleration due to gravity is about 1.6 m/s2. When at rest on a Moon-rock, the net force on the book is **zero**. (**No acceleration = zero net force.)**

# Relationship Problems

Know how the variables in F = ma are related to each other:

F and m: Directly Proportional

F and a: Directly Proportional

m and a: Inversely Proportional

In short, if the variables are on opposite sides of the =, they are directly proportional.

If the variables are on the same side of the =, they are inversely proportional.

# Relationship Problems - Questions

If an object has constant mass, the force on an object and the acceleration are **directly** proportional.

While subjected to a constant force, the mass and acceleration of an object are **inversely** proportional.

Applying a force on a 5 kg block accelerates the block. To achieve the same acceleration on a 25 kg block would require **5** times the force. (**The second block is 5 times the mass.)**

Applying a force on a 10-kg block accelerates the block on a frictionless surface. To achieve the same acceleration on a 2-kg block would require **0.2** times the force. **(The second block is 0.2 times the mass.)**

A force on a 4-kg brick accelerates the brick on a frictionless surface. To equally accelerate a 10-kg brick, one would have to apply **2.5** times the force. **(The second brick is 2.5 times the mass.)**

# Fun with Friction

Essential Facts

1) If the object is stationary, the friction force will be equal in magnitude to the applied force.

2) Friction vectors always point in the opposite direction of motion.

3) The force of friction must be subtracted from the applied force before calculating acceleration.

# Fun with Friction – Questions

If a person pushes on a desk with 50 N of force and the desk does not move, what is the force of friction between the desk and the floor? **50 N (Since the desk is in equilibrium, the forces are balanced.)**

Once the desk is moving, it is easier to keep it moving. The same person pushes with 30 N of force to keep the desk moving at a constant speed. What is the force of friction between the desk and the floor? **30 N** In what direction does the friction force act?  **Opposite of the direction of motion.**

A 75 N force accelerates a 5-kg chair across a floor at 10 m/s/s. What is the magnitude of the friction force?

**Ans:** **25 N First, calculate the force required to accelerate the chair without friction. F = ma = 5 \* 10 = 50 N. How much force is left over? 75 N – 50 N = 25 N So, 50 N go toward accelerating the chair, and 25 N of force is required to counteract the friction.**

A friction force of 30 N exists when a 20-kg desk is sliding across a floor. What force would be required to accelerate the desk at 6 m/s2?

**Ans:** **150 N First, calculate the force required to accelerate the chair without friction. F = ma = 20 \* 6 = 120 N. We still have to counteract friction, so we have to add 30 N of force. 120 N + 30 N = 150 N**

You push with 27 N on a 10-kg chest, and there is a 7 N force of friction. How fast will the chest accelerate?

**Ans: 2 m/s2 First, subtract the force of friction from the total force. 27 N – 7 N = 20 N So, 7 N is wasted on friction, and 20 N goes toward accelerating the chest. Now, plug into F = ma**

**20 = 10 \* a a = 2 m/s2**

# F = ma: Plug and Chug . . .

There will be several problems that require you to use F = ma. You will be given two of the values and will have to solve for the third. Knowing the units that each value is measured in will be helpful in determining where to plug things in.

Example: A child pulls on a 50 kg sled with 20 N of force. What is the acceleration of the sled?

Solution: kg is a measure of mass, so substitute 50 in for m.

N is a measure of force, so plug 20 in for F.

F = ma

20 = 50 a (divide both sides by 50 to solve for a) a = .4 m/s2

# F = ma: Plug and Chug . . . Questions

A crate is subjected to a 50 N force and is accelerated at 5 m/s2. What is the mass of the crate?

**m = 10 kg**

What force is required to accelerate a 49.6 kg crate at 3.2 m/s2?

**F = 158.7 N**

If an 8 N force is applied to a 2-kg chair, what is the acceleration of the chair?

**a = 4 m/s2**

# Chapter 7: Newton’s Third Law

Newton’s Third Law: Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first object.

Essential info:

1) Forces always occur in pairs.

2) Action – reaction forces are always in the opposite direction and equal in magnitude.

3) Action – reaction forces never act on the same object. They come from two different objects exerting forces on each other.

# Action – Reaction Pairs – Questions

If I push against the wall with my hand with 10 N of force, what is the reaction force? **The reaction force is a 10 N force of the wall pushing on your hand.**

A person is standing on the ground, and gravity pulls them toward the center of the Earth with a force equal to their weight. What is the reaction force? **The reaction force is the person pulling on the Earth with a force equal to the person’s weight.**

If a child pulls on a wagon and the wagon pulls back with an equal amount of force, why can the child and wagon move forward?  **The two forces do not cancel each other out. Action/reaction pairs never act on the same object. We must compare the two forces acting on the child to see what is going on. The first force is the friction force between the girl’s shoe and the ground. This is what propels the child forward. The force of the wagon on the child holds her back. If the friction force is greater than the wagon force, then the child will be able to go forward.**