Name: KEY Date:_____ Period:_____

Physics Unit 6 Study Guide Newton's Laws

Essential Questions:

1) What effect does a net force have on motion?
2) Why is a net force not needed for an object to continue to move?
3) What must be necessary for a system to be in equilibrium?

Words to define!

Force: a push or pull on an object with mass that causes it to change velocity

Newtons: a unit of force roughly equal to the weight of an apple or two golf balls

Inertia: the change in motion, including a change in direction resist to

Net Force: the force that is left over after you add up all the forces on an object

Weight: the force due to gravity acting on an object

Normal Force: the force that repels an object making contact with it

Free-Body Diagram: a picture illustrating the forces on an object by using vectors

Balanced Forces: when all forces "cancel out", a.k.a. $F_{net} = 0$

Equilibrium: when forces are balanced

Equations to use

$\Sigma F = ma$

$F_g = mg$

Skills to have!

S1 – Free-Body Diagrams – These diagrams help to organize a scenario where forces are acting on an object or a system.

To draw a Free-Body Diagram:

1) Identify your system that forces are acting on and represent that system with a dot or box.
2) Determine which direction is positive and which is negative.
3) Draw vectors starting from the dot to represent the forces with their respective directions and label them. Other vectors (i.e. net force, acceleration, etc.) can be drawn next to the Free-Body Diagram but not on it.

S2 – Newton's 2nd Law – After drawing a Free-Body Diagram, determine the forces acting in each direction (x- and y-) and add the forces together separately for each of those directions to

find the net force for each direction. Keep in mind which forces are pointed in the positive direction and which are in the negative. These positives and negatives need to be included when adding the forces.

S3 – Be able to logically progress (either forward or backward) through the following deductive reasoning:

A)

1) Use the direction of the velocity for an object and whether it's speeding up, slowing down, or moving with constant motion to determine the direction of acceleration,

2) Use the direction of the acceleration to determine the direction of the net force,

3) Based on the direction of the net force, determine which forces on a Free-Body Diagram are larger than other forces.

B)

1) Based on which forces are larger than the others, determine the direction of the net force.

2) Use the direction of the net force to determine the direction of the acceleration.

3) Use the directions of the velocity and acceleration to determine whether the object is speeding up, slowing down, or moving with constant motion.

Concepts to know!

C1 – The implication of Newton's 1st Law (the Law of Inertia) is that an object that is in motion does not need a force to continue moving. Oftentimes, we see objects that slow down naturally and therefore will need a force to keep moving. The reason that objects slow down is usually because of friction. So, the force that is being applied to an object is NOT necessarily to keep it moving but ACTUALLY it's to simply balance or cancel the force of friction so that the object's inertia will allow the object to continue moving at a constant speed.

C2 – According to Newton's 2nd Law ($\Sigma F = ma$), if an object is not accelerating, then there is no net force acting on it. This DOES NOT mean that there are no forces! This simply means that all of the forces are balanced; in other words, the forces all cancel each other.

C3 – Newton's 3rd Law (Law of Action/Reaction) only talks about the forces between two objects. If you know one force between two objects, the reaction force is determined by simply switching the two objects. For example, if you are standing on the floor, then the floor is applying an upward force on you and the reaction force is that you are applying a downward force on the floor . If you can remove one force without eliminating the reaction force, then the forces are NOT action/reaction forces.

Example Problems:

1. What are Newton's three laws (make sure you know them based on law number)
   a. Newton's First Law
   An object at rest stays at rest and an object in motion stays in motion unless acted upon by an outside force
   b. Newton's Second Law
   $F=ma$

   c. Newton's Third Law
   For every action there is an equal and opposite reaction.

2. You are walking across the room and accidently hit your toe. Your toe starts to hurt. Which law explains why your toe hurts?
   3rd, the force of your toe on the wall is equal to the force of the wall on your toe.

3. You are driving your car in the snow and hit a patch of ice. Your car starts to skid and does not stop until you hit pavement. Which law explains why your car will continue move at a constant rate until it hits the pavement?
   1st, the pavement-to-tire friction is the outside force that changes the motion of your car in motion

4. You are traveling East, but your Net Force, is to the West. Is your car speeding up, slowing down, or at constant velocity?
   Slowing down, the force is working against your motion.

5. What is the net force on a system that has a net force of 0N.
   0 N

6. When an object is accelerating, are the forces balanced or unbalanced? When an object is not accelerating, are the forces balanced or unbalanced?
   If it is accelerating, then forces are unbalanced ($F=ma$). If it is not accelerating, then forces are balanced.

7. What is the weight of an object that weighs 10 kg?
   $F=ma \quad F=(10kg)(9.8m/s^2)=98\,N$

8. If an object weighs 50N, what is the object's mass?

$$m=\frac{F}{a}=\frac{50N}{9.8m/s^2}=5.1\,kg$$

9. A ball falls out of a tree and has a weight of 10N. If the air resistance is 2N, what is the Net force on the ball?

10N − 2N = 8N down

10. Draw the free body diagram of a car driving down the road.

11. Draw the free body diagram of a book sitting on a table.

12. You are pushing a book the right with a force of 40N, and your friend is pushing with 30N. What force is needed to make the forces balanced?

You'd need 70N left

13. You and your friend decide to start playing tug of war in the backyard. Your mass is 80kg and your friend's mass is 90kg.
    a. If you are being pulled so you have an acceleration of 1.5m/s^2, what is the amount of Force being exerted on you?

$F = ma$ $\quad F = (80kg)(1.5 m/s^2) = 120 N$

    b. Based on the force that is being applied to you, what is the acceleration of your friend?

$a = \frac{F}{m}$ $\quad a = \frac{120 N}{90 kg} = 1.3 m/s^2$

14. You and your friend decide to start playing tug of war in the backyard. Your mass is 70kg and your friend's mass is 85kg.
    a. If you are being pulled so you have an acceleration of 2.3 m/s^2, what is the amount of Force being exerted on you?

$F = ma$ $\quad F = (70 kg)(2.3 m/s^2) = 161 N$

    b. Based on the force that is being applied to you, what is the acceleration of your friend?

$a = \frac{F}{m}$ $\quad a = \frac{161 N}{85 kg} = 1.9 m/s^2$

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Newton's Laws and Forces Review

Newton's Laws:

1. An object at rest stays at rest and an object in motion stays in motion unless acted upon by an outside force.
2. $F = ma$ 

3. For every action there is an equal and opposite reaction.

When Jane drives to work, she always places her purse on the passenger's seat. By the time she gets to work, her purse has fallen on the floor in front of the passenger seat. One day, she asks you to explain why this happens in terms of physics. What do you say?

Newton's 1st Law says an object at rest stays at rest unless acted upon by an outside force. the car comes to a stop but the purse slides forward because it wants to remain in motion.

You are waiting in line to use the diving board at your local pool. While watching people dive into the pool from the board, you realize that using a diving board to spring into the air before a dive is a good example of Newton's third law of motion. Explain how a diving board illustrates Newton's third law of motion.

The force of you on the diving board is equal to the force of the diving board on you.

You know the mass of an object and the force applied to the object to make it move. Which of Newton's laws of motion will help you calculate the acceleration of the object?

The second law ($F=ma$).

What is the rate of acceleration of a 2,000-kilogram truck if a force of 4,200 N is used to make it start moving forward?

$$a = \frac{F}{m} = \frac{4200\ N}{2000\ kg} = 2.1\ m/s^2$$

What is the acceleration of a 0.30 kilogram ball that is hit with a force of 25 N?

$$a = \frac{F}{m} = \frac{25\ N}{0.30\ kg} = 83.3\ m/s^2$$

How much force is needed to accelerate a 68 kilogram-skier at a rate of 1.2 m/s^2 ?

$$F = ma = (68\ kg)(1.2\ m/s^2) = 81.6\ N$$

What is the mass of an object that requires a force of 30 N to accelerate at a rate of 5 m/s^2 ?

$$m = \frac{F}{a} = \frac{30\ N}{5\ m/s^2} = 6\ kg$$

Draw the following free body diagrams:

- A book sitting on a table

- A block being pushed to the right off of a table

- A ball falling off of a tree (include air resistance)

What is the net force on a ball falling through the air, if it has a weight of 30N and the air resistance is 20 N?

10N down

What is the weight of an object that has a mass of 5 kg?

$F = ma = (5\ kg)(9.8\ m/s^2) = 49\ N$

What is the net force of an object that is sitting on a table?

0 N, it has Normal force and Weight that cancel each other out.

When the net force on an object is 0, is the forces considered balanced, or unbalanced?

Balanced