High School Physics
2019 - 2020

Instructional Packet Set II

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Name____ Date______________

TEKS **3.P.6.A** **Physics**

MOMENTUM AND ENERGY

The student will demonstrate an understanding of momentum and energy.

(P.6) **Science concepts.** The student knows that changes occur within a physical system and applies the laws of conservation of energy and momentum. The student is expected to (A) investigate and calculate quantities using the work-energy theorem in various situations;

STANDARD REVIEW

The *net* work done by a *net* force acting on an object is equal to the *change* in the kinetic energy of the object. This important relationship is known as the **work-energy theorem**, $W_{net} = \Delta KE$, where the kinetic energy can be calculated using $KE = \frac{1}{2}mv^2$.

When you use this theorem, you must include all the forces that do work on the object in calculating the net work done. You can calculate the net work done using the following equation, $W_{net} = F_{net} d \cos\Theta$.

From the work-energy theorem, we see that the speed of the object increases if the net work done on it is positive, because the final kinetic energy is greater than the initial kinetic energy. The object's speed decreases if the net work is negative, because the final kinetic energy is less than the initial kinetic energy. The work–kinetic energy theorem allows us to think of kinetic energy as the work that an object can do while the object changes speed or as the amount of energy stored in the motion of an object.

TEKS 3.P.6.A Physics

STANDARD PRACTICE

1 When the force on an object and the object's displacement are in different directions, which component of the force does work?

A The horizontal component

B The normal component

C The component that is parallel to the displacement

D The component that is perpendicular to the displacement

2 A man has three friends help him push his stalled car on a horizontal surface. The friends push with a constant total force of 1200 N. How far must the car be pushed, starting from rest, so that its final kinetic energy is 4200 J? (Disregard friction.)

A 2.6 m

B 3.5 m

C 8.3 m

D 11 m

3 Which of the following is equal to the net work done on a body?

A The change in mechanical energy of the body

B The change in the position of the body

C The change in the kinetic energy of the body

D The change in the potential energy of the body

4 A 2.0×10^3 kg car accelerates from rest under the actions of two forces. One is a forward force of 1140 N provided by traction between the wheels and the road. The other is a 950 N resistive force due to various frictional forces. How far in meters must the car travel for its speed to reach 2.0 m/s?

Name____ Date______________

TEKS **3.P.6.B** **Physics**

MOMENTUM AND ENERGY

The student will demonstrate an understanding of momentum and energy.

(P.6) **Science concepts.** The student knows that changes occur within a physical system and applies the laws of conservation of energy and momentum. The student is expected to (B) investigate examples of kinetic and potential energy and their transformations.

STANDARD REVIEW

Kinetic energy is energy of motion and depends on speed and mass. Like all forms of energy, kinetic energy can be used to do work. The faster something is moving, the more kinetic energy it has. Also, the greater the mass of a moving object, the greater its kinetic energy is. In equation form, kinetic energy is $KE = \frac{1}{2}mv^2$.

Potential energy is stored energy. Chemical energy, electrical energy, and nuclear energy can be considered forms of potential energy because the energy is stored in particles of matter. This potential energy can be transformed into kinetic energy or other forms of potential energy. *Gravitational potential energy* is the energy an object has because of its position. It depends on weight (mass times acceleration due to gravity where $g = 9.8\ \text{m/s}^2$) and height (h). In equation form, gravitational potential energy is $PE_g = mgh$.

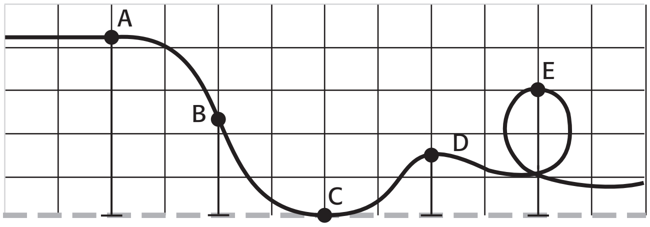
Elastic potential energy is energy stored in the position of particles of an object. For example, a stretched spring has potential energy because work has been done to change its shape. The energy of that work is turned into potential energy that can be transformed back into kinetic energy when the spring is released. In equation form, elastic potential energy is $PE_{elastic} = \frac{1}{2}kx^2$.

The *law of conservation of energy* states that energy cannot be created or destroyed. In other words, the total amount of energy in the universe never changes, although energy may change from one form to another. In equation form this law can be expressed as $E_i = E_f$. Conservation of energy is an important concept for roller coaster designer Steve Okamoto. Steve says, "Studying math and science is very important. To design a successful coaster, I have to understand how energy is converted from one form to another as the cars move along the track. I have to calculate speeds and accelerations of the cars on each part of the track. They have to go fast enough to make it up the next hill! I rely on my knowledge of geometry and physics to create the roller coaster's curves, loops, and dips."

TEKS 3.P.6.B Physics

STANDARD PRACTICE

1 The diagram below shows a roller coaster track. Points *A–E* indicate locations of the roller coaster car at different times as it travels along the track.



Which statement below is correct concerning the roller coaster along points A–E?

A The gravitational potential energy is maximum at E.

B The gravitational potential energy is maximum at C.

C The kinetic energy at C is less than the kinetic energy at B.

D The kinetic energy at E is less than the kinetic energy at D.

2 During a field investigation, a student studies kinetic and potential energy by observing apples on a tree. What type of energy do these apples have when on the tree?

A Kinetic energy

B Nuclear energy

C Elastic potential energy

D Gravitational potential energy

3 A tire swing is released from some initial height such that the speed of the tire at the bottom of the swing is 2.5 m/s. What is the initial height of the tire? Note: $g = 9.8$ m/s^2

A 0.13 m

B 0.16 m

C 0.32 m

D 3.1 m

4 A toy spring with a spring constant of 6.4 N/m has a relaxed length of 20.0 cm. When a ball is attached to the end of the spring and allowed to come to rest, the vertical length of the spring is 75.0 cm. What is the elastic potential energy stored in the spring?

Name____ Date____________

TEKS **3.P.6.C** **Physics**

MOMENTUM AND ENERGY

The student will demonstrate an understanding of momentum and energy.

(P.6) **Science concepts.** The student knows that changes occur within a physical system and applies the laws of conservation of energy and momentum. The student is expected to (C) calculate the mechanical energy of, power generated within, impulse applied to, and momentum of a physical system;

STANDARD REVIEW

Analyzing situations involving kinetic, gravitational potential, and elastic potential energy is relatively simple. We can ignore other forms of energy if their influence is negligible or if they are not relevant to the situation being analyzed. In most situations that we are concerned with, these other forms of energy are not involved in the motion of objects. In dealing with moving objects, we will find it useful to define a quantity called *mechanical energy*. The mechanical energy is the sum of kinetic energy and all forms of potential energy associated with the motion of an object or group of objects.

The work-kinetic energy theorem allows us to think of kinetic energy as the work that an object can do while the object changes speed or as the amount of energy stored in the motion of an object. The rate at which work is done is called *power*. More generally, power is the rate of energy transfer by any method.

Momentum is a word we use every day in a variety of situations. In physics this word has a specific meaning. The linear momentum of an object of mass m moving with a velocity $\mathbf{v}$ is defined as the product of the mass and the velocity. Consider a soccer player stopping a moving soccer ball. In a given time interval, he must exert more force to stop a fast ball than to stop a ball that is moving more slowly. We see that a change in momentum is closely related to force. The *impulse* is the product of the applied force and the time interval the force acts, which is equal to an object's change in momentum.

Reference Information

Momentum
$\mathbf{P} = m\mathbf{v}$

Impulse-Momentum Theorem
$\mathbf{F}\Delta t = \Delta \mathbf{p}$ or $\mathbf{F}\Delta t = \Delta \mathbf{p} = m\mathbf{v}_f - m\mathbf{v}_i$

Total Mechanical Energy
$ME = KE + PE$

Kinetic Energy
$KE = \frac{1}{2}mv^2$

Gravitational Potential Energy
$PE = mgh$

Average Power
$P_{\text{ave}} = W/\Delta t$

Work-Kinetic Energy Theorem
$W_{\text{net}} = \Delta KE$

TEKS 3.P.6.C Physics

STANDARD PRACTICE

1 A 150 g pinball rolls towards a springloaded launching rod with a velocity of 2.0 m/s to the west. The launching rod strikes the pinball and causes it to move in the opposite direction with a velocity of 10.0 m/s. What impulse was delivered to the pinball by the launcher?

A 0.75 kg•m/s to the east

B 1.2 kg•m/s to the east

C 1.8 kg•m/s to the east

D 3.0 kg•m/s to the east

2 A cart with a mass of 25.0 kg is rolling with a speed of 14 m/s. What is the magnitude of the momentum of the cart?

A 1.8 kg•m/s

B 11 kg•m/s

C 39 kg•m/s

D 350 kg•m/s

3 A mover pushes a 245 kg piano so that it accelerates uniformly from rest to 1.5 m/s in 5.00 s. What is the power delivered by the mover in this time interval?

A 55 W

B 110 W

C 280 W

D 540 W

4 A 755 N diver drops from a board 10.0 m above the water's surface. What is the diver's total mechanical energy, in joules, when he is 5.00 m above the surface of the water?

Name________________________________ Date____________

TEKS **3.P.6.D** **Physics**

MOMENTUM AND ENERGY

The student will demonstrate an understanding of momentum and energy.

(P.6) **Science concepts.** The student knows that changes occur within a physical system and applies the laws of conservation of energy and momentum. The student is expected to (D) demonstrate and apply the laws of conservation of energy and conservation of momentum in one dimension;

STANDARD REVIEW

Imagine that two cars of different masses moving with different velocities collide head on. The momentum of the cars after the collision can be predicted. This prediction can be made because momentum is always conserved, or, in other words, always remains constant. Some momentum may be transferred from one car to the other, but the total momentum remains the same. This principle is known as the *law of conservation of momentum*. In an *elastic collision* two objects collide and return to their original shapes with no loss of total kinetic energy. After the collision, the two objects move separately. In an elastic collision, both the total momentum and the total kinetic energy are conserved. When two objects collide and move together as one mass, the collision is called a *perfectly inelastic collision*. In an inelastic collision, kinetic energy is converted to internal elastic potential energy when the objects deform. Some kinetic energy is also converted to sound energy and internal energy. In an inelastic collision, the total kinetic energy does not remain constant when the objects collide and stick together.

Reference Information

Momentum $g = 9.81\ \text{m/s}^2$
$\boldsymbol{P} = m\boldsymbol{v}$

Impulse-Momentum Theorem
$\boldsymbol{F}\Delta t = \Delta \boldsymbol{p}$ or $\boldsymbol{F}\Delta t = \Delta \boldsymbol{p} = m\boldsymbol{v}_{\mathbf{f}} - m\boldsymbol{v}_{\mathbf{i}}$

Conservation of Momentum
$m_1\boldsymbol{v}_{\mathbf{1,i}} + m_2\boldsymbol{v}_{\mathbf{2,i}} = m_1\boldsymbol{v}_{\mathbf{1,f}} + m_2\boldsymbol{v}_{\mathbf{2,f}}$

Perfectly Inelastic Collision
$m_1\boldsymbol{v}_{\mathbf{1,i}} + m_2\boldsymbol{v}_{\mathbf{2,i}} = (m_1 + m_2)\boldsymbol{v}_{\mathbf{f}}$

Conservation of Mechanical Energy
$\frac{1}{2}m_1v_{1,i}^2 + \frac{1}{2}m_2v_{2,i}^2 = \frac{1}{2}m_1v_{1,f}^2 + \frac{1}{2}m_2v_{2,f}^2$

Gravitational Potential Energy
$PE_g = mgh$

TEKS 3.P.6.D Physics

STANDARD PRACTICE

1 After pushing away from each other, two objects have equal but opposite momentum. Which of the following is true for the total momentum of the system?

A It is twice the momentum of one object.

B It is zero.

C It is less than the initial momentum.

D It is greater than the initial momentum.

2 A 72.0 kg stuntman jumps from a moving car to a 2.50 kg skateboard at rest. If the velocity of the car is 15.0 m/s to the east when the stuntman jumps, what is the final velocity of the stuntman and the skateboard?

A 0.521 m/s to the east

B 14.5 m/s to the east

C 15.5 m/s to the east

D 432 m/s to the east

3 A 0.400 kg bead slides on a straight frictionless wire and moves with a velocity of 3.50 cm/s to the right, as shown below. The bead collides elastically with a larger 0.600 kg bead that is initially at rest. After the collision, the smaller bead moves to the left with a velocity of 0.70 cm/s.

What is the total kinetic energy of the system of beads after the collision?

A 1.40×10^{-4} J

B 2.45×10^{-4} J

C 4.70×10^{-4} J

D 4.90×10^{-4} J

4 The ballistic pendulum is an apparatus used to measure the speed of a projectile. An 8.0 g bullet is fired into a 2.5 kg ballistic pendulum bob, which is initially at rest, and becomes embedded in the bob. The pendulum then rises to a vertical distance of 6.0 cm. What was the initial speed of the bullet (in m/s)?

TEKS **3.P.6.E** **Physics**

MOMENTUM AND ENERGY

The student will demonstrate an understanding of momentum and energy.

(P.6) **Science concepts.** The student knows that changes occur within a physical system and applies the laws of conservation of energy and momentum. The student is expected to (E) describe how the macroscopic properties of a thermodynamic system such as temperature, specific heat, and pressure are related to the molecular level of matter, including kinetic or potential energy of atoms;

STANDARD REVIEW

According to kinetic theory, all matter is made of particles—atoms and molecules—that are constantly in motion. Because they are in motion, all particles of matter have kinetic energy. *Temperature* is a measure of average kinetic energy. Particles of matter are constantly moving, but they do not all move at the same speed. As a result, some particles have more kinetic energy than others have. When you measure an object's temperature, you measure the average kinetic energy of the particles in the object. The more kinetic energy the particles of an object have, the higher the temperature of the object.

For a monatomic gas, temperature can be understood in terms of the translational kinetic energy of the atoms in the gas. For other kinds of substances, molecules can rotate or vibrate, so other types of energy are also present. For example, a carbon dioxide molecule with vibrational energy is like a plucked guitar string. It contains both kinetic and potential energies due to the way the bonds between atoms in the molecule stretch and bend like a spring.

To measure temperature, we use a simple physical property of substances: most substances expand when their temperature increases. Thermometers use the expansion of liquids such as mercury or colored alcohol to measure temperature. These liquids expand as their temperature increases and contract as their temperature falls. As the temperature rises, the particles in the liquid inside a thermometer gain kinetic energy and move faster.
With this increased motion, the particles in the liquid move farther apart. So, the liquid expands and rises up the narrow tube.

The *specific heat capacity* of a substance is defined as the energy required to change the temperature of 1 kg of that substance by 1°C. Every substance has a unique specific heat capacity. This value tells you how much the temperature of a given mass of that substance will increase or decrease, based on how much energy is added or removed as heat.

Pressure is a measure of how much force is applied over a given area. But what is providing this force? In kinetic theory, gas particles are likened to a collection of billiard balls that constantly collide with one another. This simple model is successful in explaining many of the macroscopic properties of a gas. For instance, as these particles strike a wall of a container, they transfer some of their momentum during the collision. The rate of transfer of momentum to the container wall is equal to the force exerted by the gas on the container wall, in accordance with the impulse-momentum theorem.

Name____ Date_____________

TEKS 3.P.6.E **Physics**

STANDARD PRACTICE

1 A group of students painted four cans, placed 500 grams of water in each can, and measured the temperature of the water as shown in Figure 1.They placed the cans on a sunny windowsill for two hours and then measured the temperature again (Figure 2).

FIGURE 1

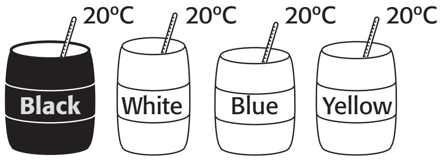
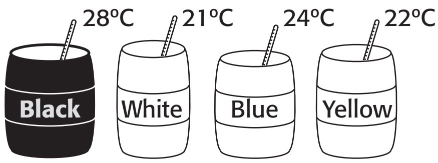


FIGURE 2



Which statement correctly describes the significance of the temperature changes shown?

A The water molecules in the white can slowed down the most.

B The water molecules in the black can had the largest increase in average kinetic energy.

C The water molecules in the blue can have a lower average potential energy than the water molecules in the white can.

D The water molecules in the yellow can are moving at half the speed of the water molecules in the blue can.

2 Which of the following statements is true of the cans in Figure 2?

A All of the particles in the blue can have the same kinetic energy.

B The average kinetic energy of molecules in the white can is greater than in the yellow can.

C The kinetic energy of every particle in the black can is greater than that of every particle in the white can.

D The temperature of the black can indicates the average kinetic energy of water molecules in the can.

Name______________________________ Date__________

TEKS 3.P.6.E Physics

3 A student measured out 1 kg samples of each substance below on a triple beam balance. Next, the student heated each sample on a hot plate, increasing the temperature of each sample by 10°C as measured with a Celsius thermometer. Based on the given specific heat capacities, which substance required more heat input for this temperature increase?

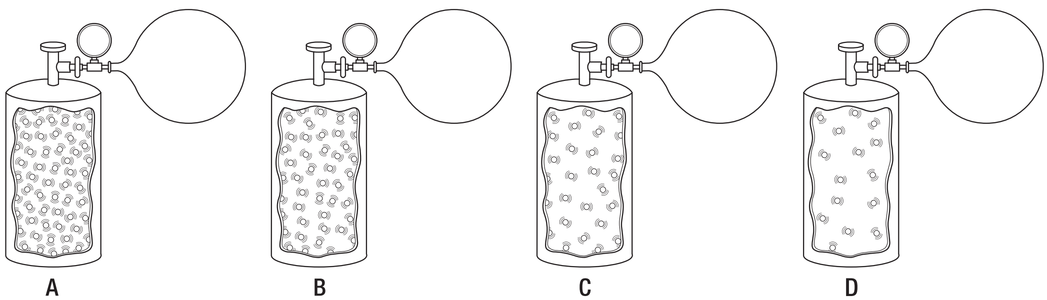
A Water, $c_p = 4.186 \times 10^3$ J/kg•°C

B Silver, $c_p = 2.34 \times 10^2$ J/kg•°C

C Copper, $c_p = 387$ J/kg•°C

D Aluminum, $c_p = 899$ J/kg•°C

4 The following graphic shows a full tank of helium (A), the same tank after it has filled 10 balloons (B), the same tank after it has filled 20 balloons (C), and the same tank after it has filled 30 balloons (D). In which tank is the greatest pressure being exerted on the tank's inner surface?



A Tank A

B Tank B

C Tank C

D Tank D

Name______________________________ Date__________

TEKS **3.P.6.F** **Physics**

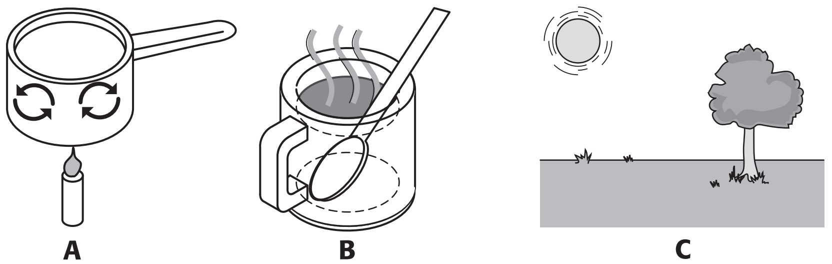
MOMENTUM AND ENERGY

The student will demonstrate an understanding of momentum and energy.

(P.6) **Science concepts.** The student knows that changes occur within a physical system and applies the laws of conservation of energy and momentum. The student is expected to (F) contrast and give examples of different processes of thermal energy transfer, including conduction, convection, and radiation;

STANDARD REVIEW

Heat is the transfer of thermal energy from one object to another. Heat flows by convection, conduction, or radiation. It always flows from an object at a higher temperature to an object at a lower temperature unless work is done on the system.



Convection (contents of pot in illustration A) is the transfer of thermal energy by the movement of a liquid or a gas. When you boil water in a pot, the water moves in circular patterns because of convection, as shown above. The water at the bottom of a pot on a stove burner gets hot because it is touching the pot. As it heats, the water becomes less dense. The warmer water rises through the denser, cooler water above it. At the surface, the warm water begins to cool and become denser. The cooler water then sinks back to the bottom. It is heated again, and the cycle begins again.

Thermal conduction (the spoon in illustration B) is the transfer of thermal energy from one substance to another through direct contact. When objects touch each other, their particles collide. When particles collide, particles with higher kinetic energy transfer energy to those with lower kinetic energy. This transfer makes some particles slow down and other particles speed up until all particles have the same average kinetic energy.

A third way thermal energy is transferred is radiation (from the sun to Earth in illustration C), the transfer of energy by electromagnetic waves, including visible light and infrared radiation. Unlike conduction and convection, radiation can involve either an energy transfer through matter or an energy transfer through the vacuum of empty space.

Name____ Date____________

TEKS 3.P.6.F **Physics**

STANDARD PRACTICE

1 Eventually, a hot cup of coffee is the same temperature as the air of the room in which the coffee is located. Why does this happen?

A Energy is transferred from another source until the temperature becomes the same.

B Energy is transferred from the air to the coffee until the temperature becomes the same.

C Energy is transferred from the coffee to the air until the temperature becomes the same.

D Energy moves equally back and forth between the coffee and the air until the temperature becomes the same.

2 Two objects at different temperatures are in contact. Which of the following happens to their thermal energies?

A Their thermal energies remain the same.

B Thermal energy passes from the cooler object to the warmer object.

C Thermal energy passes from the warmer object to the cooler object.

D Thermal energy passes back and forth equally between the two objects.

3 As a spoon in a bowl of hot soup becomes warmer, through which process is heat being transferred to the spoon?

A Conduction

B Convection

C Insulation

D Radiation

4 Just beneath the sun's visible surface, called the photosphere, is a zone where energy is transported by the rising of hot gas and the falling of cool gas. The tops of these circulation cells account for the grainy appearance of the photosphere. What heat transfer process is occurring in this zone?

A Radiation

B Conduction

C Induction

D Convection

Name____ Date____________

TEKS **3.P.6.G** **Physics**

MOMENTUM AND ENERGY

The student will demonstrate an understanding of momentum and energy.

(P.6) **Science concepts.** The student knows that changes occur within a physical system and applies the laws of conservation of energy and momentum. The student is expected to (G) analyze and explain everyday examples that illustrate the laws of thermodynamics, including the law of conservation of energy and the law of entropy;

STANDARD REVIEW

The principle of energy conservation that takes into account a system's internal energy as well as work and heat is called the first law of thermodynamics. A system's internal energy can be changed by transferring energy as either work, heat, or a combination of the two. Everyday examples that illustrate the first law of thermodynamics include refrigerators and air conditioners, as well as heat pumps and diesel engines. A refrigerator performs mechanical work to create temperature differences between its closed interior and its environment (the air in the room). This process leads to the transfer of energy as heat. A heat engine does the opposite: it uses heat to do mechanical work. Both of these processes have something in common: they are examples of cyclic processes.

Reference Information

Work Done by a Gas $W = P\Delta V$	**The First Law of Thermodynamics** $\Delta U = Q - W$
Efficiency of a Heat Engine $eff = \frac{W_{net}}{Q_h} = \frac{Q_h - Q_c}{Q_h} = 1 - \frac{Q_c}{Q_h}$	**Area of a Circle** $A = \pi r^2$

It is impossible to construct a heat engine that, operating in a cycle, absorbs energy from a hot reservoir and does an equivalent amount of work. This requirement is the basis of what is called the second law of thermodynamics, which can be stated as follows: *No cyclic process that converts heat entirely into work is possible*. In other words, some energy must always be transferred as heat to the system's surroundings. In thermodynamics, a system left to itself tends to go from a state with a very ordered set of energies to one in which there is less order. The measure of a system's disorder is called the entropy of the system. The greater the entropy of a system is, the greater the system's disorder. The entropy of a system tends to increase. Because of the connection between a system's entropy, its ability to do work, and the direction of energy transfer, the second law of thermodynamics can also be expressed in terms of entropy change. As a system becomes more disordered, less of its energy is available to do work. This law applies to the entire universe, not only to a system that interacts with its environment. So, the second law can be stated as follows: *The entropy of the universe increases in all natural processes*.

TEKS 3.P.6.G Physics

STANDARD PRACTICE

1 In which of the following processes is no work done?

A Water is boiled in a pressure cooker.

B A refrigerator is used to freeze water.

C An automobile engine operates for several minutes.

D A tire is inflated with an air pump.

2 A thermodynamic process occurs in which the entropy of a system decreases. From the second law of thermodynamics, what can you conclude about the entropy change of the environment?

A The entropy of the environment decreases.

B The entropy of the environment increases.

C The entropy of the environment remains unchanged.

D There is not enough information to state what happens to the environment's entropy.

3 Which of the following is a violation of the law of entropy in which the order of the universe would actually be spontaneously increasing?

A Letting air out of one of the tires on a car

B A bead of sweat evaporating from your skin

C Freezing a sample of water until it becomes an ice cube

D A machine that produces more work or energy than it consumes

4 If a heat engine takes in 4565 kJ and gives up 2955 kJ during one cycle, what is the engine's efficiency?

Name____ Date____________

GRAVITATIONAL, ELECTRICAL, MAGNETIC, AND NUCLEAR FORCES

The student will demonstrate an understanding of gravitational, electrical, magnetic, and nuclear forces.

(P.5) **Science concepts.** The student knows the nature of forces in the physical world. The student is expected to (A) research and describe the historical development of the concepts of gravitational, electromagnetic, weak, nuclear, and strong nuclear forces;

STANDARD REVIEW

Scientists identify four fundamental forces in nature. These forces are gravity, the electromagnetic force, the strong nuclear force, and the weak nuclear force. The fundamental forces vary widely in strength and the distance over which they act.

Published on July 5, 1687, Isaac Newton's *Principia* stated quantitatively that the magnitude of the gravitational force between two masses was proportional to the product of the masses divided by the distance of separation squared. In 1873, James Clerk Maxwell linked the forces of electricity and magnetism, once believed to be separate, in his publication *Treatise on Electricity and Magnetism*. Gravitational and electromagnetic forces act over longer distances. Their effects extend an infinite distance, although these effects decrease rapidly as the distance between objects increases.

Around 1934, puzzled as to how a nucleus full of protons did not fly apart due to repulsion forces, physicists developed the concept of a "nuclear force" that holds it together. Today, we understand that the strong nuclear force holds together the protons and neutrons in the nuclei of atoms and is the strongest of all the forces. However, it is negligible over distances greater than the size of an atomic nucleus. The weak nuclear force acts over even smaller distances, about the diameter of a proton. It is about one-millionth as strong as the strong force. The electromagnetic force is about 1/100 the strength of the strong nuclear force. The gravitational force is much weaker than the electromagnetic force. Consider a proton and an electron in an atom. The electromagnetic force is about 10^{40} times as great as the gravitational force between them! That is why the effects of the electromagnetic force can be observed in the interactions of atoms, while the gravitational force can only be observed in the interactions of very large objects.

TEKS 2.P.5.A Physics

STANDARD PRACTICE

1 What keeps the protons in an atomic nucleus from flying away from one another?

A They are attracted to one another by electric forces.

B Neutrons bond with protons, holding the protons together.

C The attraction between electrons and protons holds the nucleus together.

D The strong nuclear force is stronger than the repulsive electric force at short distances.

2 How does the force that holds the nucleus together compare to the electromagnetic force that causes protons and electrons to stay together in atoms?

A The nuclear force is equal to the electromagnetic force.

B The nuclear force is stronger than the electromagnetic force under all conditions.

C The nuclear force is stronger than the electromagnetic force at very short distances but equal at longer distances.

D The nuclear force is stronger than the electromagnetic force at very short distances but weaker at longer distances.

3 Which is the weakest of the four fundamental forces?

A Electromagnetic

B Gravitational

C Strong nuclear

D Weak nuclear

4 The strength of the strong nuclear force is about how many times stronger than the electromagnetic force?

Name____ Date_____________

TEKS **2.P.5.B** **Physics**

GRAVITATIONAL, ELECTRICAL, MAGNETIC, AND NUCLEAR FORCES

The student will demonstrate an understanding of gravitational, electrical, magnetic, and nuclear forces.

(P.5) **Science concepts.** The student knows the nature of forces in the physical world. The student is expected to (B) describe and calculate how the magnitude of the gravitational force between two objects depends on their masses and the distance between their centers;

STANDARD REVIEW

Earth and many of the other planets in our solar system travel in nearly circular orbits around the sun. Thus, a centripetal force must keep them in orbit. One of Isaac Newton's great achievements was the realization that the centripetal force that holds the planets in orbit is the very same force that pulls an apple toward the ground—gravitational force.

Newton developed the following equation to describe quantitatively the magnitude of the gravitational force if distance r separates masses m_1 and m_2:

Newton's Law of Universal Gravitation

$$F_g = \frac{Gm_1m_2}{r^2},\ G = 6.673 \times 10^{-11}\ \frac{\text{N} \bullet \text{m}^2}{\text{kg}^2}$$

G is called the *constant of universal gravitation*. The value of *G* was unknown in Newton's day, but experiments have since determined it. Newton demonstrated that the gravitational force that a spherical mass exerts on a particle outside the sphere would be the same if the entire mass of the sphere were concentrated at the sphere's center. When calculating the gravitational force between Earth and our sun, for example, you use the distance between their centers. Gravitational force always attracts objects to one another. The force that the sun exerts on Earth is equal and opposite to the force that Earth exerts on the sun. This relationship is an example of Newton's third law of motion. Gravitational force exists between any two masses, regardless of size.

Name____ Date_____________

TEKS **2.P.5.B** **Physics**

STANDARD PRACTICE

1 The planet Venus has a mass of 4.87×10^{24} kg, and Earth has a mass of 5.97×10^{24} kg. How far apart are the two planets when they exert a gravitational force of 1.12×10^{18} N on one another?

A 1.54×10^{3} m

B 4.16×10^{10} m

C 1.72×10^{21} m

D 4.66×10^{28} m

2 Which of the following is an *incorrect* interpretation of the expression $a_g = g = Gm_E/r^2$?

A Gravitational field strength changes with an object's distance from the center of Earth.

B Free-fall acceleration changes with an object's distance from the center of Earth.

C Free-fall acceleration is independent of the falling object's mass.

D Free-fall acceleration is dependent on the falling object's mass.

3 According to the universal law of gravitation, if you halve the distance between two objects, how does the gravitational force between them change?

A Increases by a factor of 2

B Increases by a factor of 4

C Decreases to $\frac{1}{2}$ the original force

D Decreases to $\frac{1}{4}$ the original force

4 What is the magnitude of the gravitational force (in newtons) a 66.5 kg person would experience while standing on the surface of Pluto?

Object	Mass	Radius
Earth	5.97×10^{24} kg	6.38×10^{6} m
Mars	6.42×10^{23} kg	3.40×10^{6} m
Pluto	1.25×10^{22} kg	1.20×10^{6} m

Name____ Date____________

TEKS 2.P.5.C Physics

GRAVITATIONAL, ELECTRICAL, MAGNETIC, AND NUCLEAR FORCES

The student will demonstrate an understanding of gravitational, electrical, magnetic, and nuclear forces.

(P.5) **Science concepts.** The student knows the nature of forces in the physical world. The student is expected to (C) describe and calculate how the magnitude of the electrical force between two objects depends on their charges and the distance between them;

STANDARD REVIEW

Two charged objects near one another may experience acceleration either toward or away from each other because each object exerts a force on the other object. This force is called the *electric force*. It seems obvious that the distance between two objects affects the magnitude of the electric force between them. Further, it is reasonable that the amount of charge on the objects will also affect the magnitude of the electric force. What is the precise relationship between distance, charge, and the electric force?

In the 1780s, Charles Coulomb conducted a variety of experiments in an attempt to determine the magnitude of the electric force between two charged objects. Coulomb found that the electric force between two charges is proportional to the product of the two charges. Coulomb also found that the electric force is inversely proportional to the square of the distance between the charges. The following equation, known as Coulomb's law, expresses these conclusions mathematically for two charges separated by a distance, r.

$$F_{electric} = \frac{k_C q_1 q_2}{r^2}$$

$$\text{where } k_C = 8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$$

Note that Coulomb's law gives the magnitude of the force between charges. The direction of the force must be determined as well. The electric force between two objects always acts along the line that connects their centers of charge. Like charges repel each other, and unlike charges attract each other. Also, note that Coulomb's law applies exactly only to point charges or particles, and to spherical distributions of charge. When applying Coulomb's law to spherical distributions of charge, use the distance between the centers of the spheres as r.

Name____ Date____________

TEKS **2.P.5.C** **Physics**

STANDARD PRACTICE

1 By what factor does the electric force between two charges change when the distance between them is doubled?

A 4

B 2

C $\frac{1}{2}$

D $\frac{1}{4}$

2 Two charged particles of $+5.0 \times 10^{-15}$ C and $+4.7 \times 10^{-15}$ C exert a repulsive force on each other of 350 N. What is the distance between the two charges?

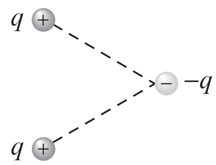
A 6.0×10^{-22} m

B 2.5×10^{-11} m

C 8.8×10^{-5} m

D 4.1×10^{10} m

3 In which direction will the electric force from the two equal positive charges move the negative charge shown below?



A To the left

B To the right

C Upward

D Downward

4 An alpha particle (charge = $+2.0e$) is sent at high speed toward a gold nucleus (charge = $+79e$). What is the electric force acting on the alpha particle when the alpha particle is 2.0×10^{-14} m from the gold nucleus? ($e = 1.6 \times 10^{-19}$ C)

Name____ Date____________

GRAVITATIONAL, ELECTRICAL, MAGNETIC, AND NUCLEAR FORCES

The student will demonstrate an understanding of gravitational, electrical, magnetic, and nuclear forces.

(P.5) **Science concepts.** The student knows the nature of forces in the physical world. The student is expected to (D) identify examples of electric and magnetic forces in everyday life;

STANDARD REVIEW

You have probably noticed that after you run a plastic comb through your hair on a dry day, the comb attracts strands of your hair or small pieces of paper. When materials behave this way, they are said to be *electrically charged*. You can give your body an electric charge by vigorously rubbing your shoes on a wool rug or by sliding across a car seat. You can then remove the charge on your body by lightly touching another person. Plastic wrap becomes electrically charged as it is pulled from its container, and, as a result, it is attracted to objects such as food containers. In a car factory, a fresh coat of paint is applied to an automobile by spray guns. With ordinary spray guns, any paint that does not happen to hit the body of the car is wasted. A special type of spray painting, known as *electrostatic spray painting*, utilizes electric force to minimize the amount of paint that is wasted. The paint is given a negative charge and the car is given a positive charge. Thus, the paint is attracted to the car.

Electric forces and magnetic forces are related. When a compass is held close to a wire with an electric current flowing through it, the compass needle no longer points north because an electric current produces a magnetic field. The motion of electrons in the wire produces a magnetic field around the wire. Permanent magnets and electromagnets are used in many everyday and scientific applications. Huge electromagnets are used to pick up and move heavy loads, such as scrap iron at a recycling plant. You have probably seen a variety of magnet shapes, such as horseshoe magnets, bar magnets, and the flat magnets frequently used to attach items to a refrigerator. All types of magnets attract iron-containing objects such as paper clips and nails. Iron objects are most strongly attracted to the ends of such a magnet. These ends are called *poles*; one is called the *north pole*, and the other is called the *south pole*. If a bar magnet is suspended from its midpoint so that it can swing freely in a horizontal plane, it will rotate until its north pole points north and its south pole points south. Magnets are also used in meters, motors, and loudspeakers. Magnetic tapes are routinely used in sound- and video-recording equipment, and magnetic recording material is used on computer disks.

TEKS 2.P.5.D Physics

STANDARD PRACTICE

1 Which geographic region of Earth corresponds to the north pole of Earth's magnetic field?

A The Western Hemisphere

B The Eastern Hemisphere

C The North Pole

D The South Pole

2 Two balls are suspended by parallel strings so that they hang at the same level as shown in the figures below. Which figure shows balls that have the same charge?

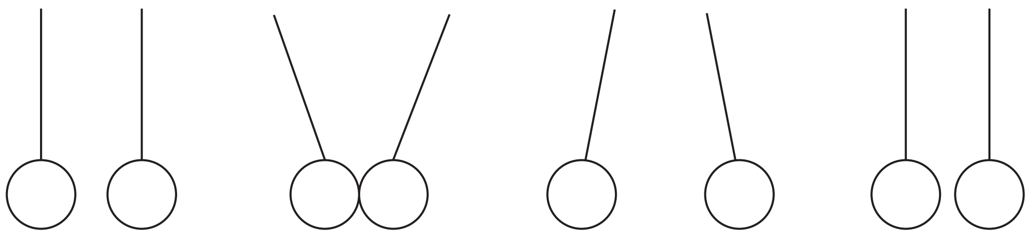


Figure A Figure B Figure C Figure D

A Figure A

B Figure B

C Figure C

D Figure D

3 If you are standing at Earth's magnetic north pole and holding a bar magnet that is free to rotate in three dimensions, which direction will the south pole of the magnet point?

A Straight up

B Straight down

C Parallel to the ground, toward the north

D Parallel to the ground, toward the south

TEKS 2.P.5.D Physics

4 The SI unit for magnetic field strength is the tesla (T). The cgs unit for magnetic field strength is the gauss (G). The Earth's magnetic field has a magnetic field strength of approximately 0.5 gauss. The typical refrigerator magnet in your home has a magnetic field strength of about 5 mT. Given that 1 gauss = 1×10^{-4} tesla, how many times stronger is the typical refrigerator magnet than the Earth's magnetic field?