Name: ________________________ Date: ________ Group: _________

Magnets and Potential Energy

1 Potential energy (PE), also known as stored energy, is the energy stored within a physical system. Since energy can be defined as the ability to do work or cause movement, you can think of potential energy as work waiting to happen. All objects at rest have some type of PE, and the PE of an object changes with its position. What does this mean? The PE that an object has is measured in relation to a specific starting point, or reference point.

2 Let's look at some examples. Sometimes PE is described as chemical potential energy—the type of PE found in the chemical bonds of all matter. The amount of chemical PE an object has depends on the types of chemical bonds found in that matter. Sometimes PE is described as elastic potential energy. The amount of elastic PE in that system depends on how far the object is stretched or compressed. Sometimes PE is described as gravitational potential energy—the type of PE that is based on how far an object is from the ground.

3 As you can imagine, the most common examples of PE are related to gravity. For example, a book on the table has more gravitational potential energy than a book lying on the floor. A roller coaster at the top of the track has more potential energy than at the bottom of the track. An apple high in a tree has farther to fall than an apple low in a tree. The force of gravity will do more work to bring it to the ground. Therefore, the higher apple will have greater potential energy than the lower apple. In any situation, the farther the object is from the ground, the more PE it has.

4 However, it is important to note that PE applies to all forces acting at a distance. Acting at a distance means that contact between objects is not required for a force to work. Forces acting at a distance include gravity, electricity, and magnetism. Magnetism has some interesting uses related to potential energy.

5 How do magnets work? Remember that each magnet produces its own magnetic field. The orientation of the field gives each magnet two poles, often called the north pole and the south pole. When two magnets come close to each other, their fields interact and produce a force that can act over a distance. When the north pole of one magnet faces towards the north pole of another magnet, the two magnets will repel each other, or push each other away. When the north pole of a magnet faces the south pole of another magnet, the two magnets will attract each other.

6 Another important thing about potential energy is that physical systems tend to act in a way that reduces the stored potential energy. In the case of gravitational PE, an unsupported object will fall and lower its potential energy. Just like a ball that drops when it is let go, a magnet that is free to move will align itself with another, stronger magnetic field to reach the state of lowest PE. This is demonstrated each time the needle of a compass, itself a magnet, spontaneously lines up with Earth's magnetic field.

7 What does this really tell us about potential energy and magnets? Gravitational PE only depends on distance, but magnetic PE depends on distance and orientation in the magnetic field. When a south pole of one magnet approaches the north pole of another, the magnetic fields are aligned. This makes an attractive force between the two magnets. The farther apart they are, the higher their potential energy. If allowed to move freely, they will snap together to minimize PE, just like the ball falling to the ground to minimize gravitational PE. When the north pole of one magnet approaches the north pole of another, the magnets' fields are in exact opposite alignment. They repel each other because the field produces a repulsive force pushing them apart. In this case, the closer they are, the higher their potential energy will be. If allowed to move somewhat freely, they will either move as far apart as possible or one will swing around to change its orientation. Both actions will result in lower PE in the system.

8 Magnets come in two varieties, permanent and temporary. The small magnets used to hold notes to refrigerator doors are examples of permanent magnets, while temporary magnets use electricity to create a magnetic field. A temporary magnet can be turned on or off, and the location of the north and south poles can be switched. Larger electric currents make stronger magnets.

9 Maglev, short for magnetic levitation, trains use magnets and PE to make them run along a track. These trains have no wheels, but instead, the track has magnetic coils pointing towards the rail car. The railcar also has magnets pointing towards the track. When the track and train magnets are on, they repel each other, and the railcar lifts off the track between one and ten centimeters. The current from the coils in the track constantly changes, which changes the orientation of the magnetic field of the temporary magnets along the track. The coils in front of the train use magnetic force to pull the train forward, while the coils behind the train use magnetic force to push the train forward. This type of train system uses magnetic PE to move the train along the track with very little friction.

1 Gravitational potential energy is related to —

- **A** what an object is made of.
- **B** an object’s motion.
- **C** an object’s position.
- **D** an object’s color.

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2 Which statement about potential energy is correct?

- **A** The closer an object is to the ground, the greater the PE.
- **B** The farther an object is from the ground, the greater the PE.
- **C** The only form of PE is gravitational PE.
- **D** Potential energy is the energy of motion.

3 Use what you have learned in the reading to answer the following question. The point of a compass needle points to the Earth's North Pole. The point has in the compass needle has —

A the same polarity as the Earth's North Pole.

B the opposite polarity from the Earth's North Pole.

C no polarity.

D unlimited polarity.

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4 A student holds two iron magnets, one in each hand. The south pole of one magnet is pointed towards the south pole of the other magnet. As the magnets get closer to each other, they will

A attract each other more strongly.

B attract each other more weakly.

C repel each other more strongly.

D repel each other more weakly.

5 The PE of a magnet in the presence of another magnet is related to —

A only how close the magnets are together.

B only the direction in which the poles point.

C how close the magnets are together and how fast they are moving.

D how close the magnets are together and which direction the poles point.

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6 Maglev trains use magnetic PE to help them move along the track. Which statement below shows how they do this?

A The magnets in the train and the track repel each other.

B The magnets in front of the train pull the train forward.

C The magnets behind the train push the train forward.

D All of the above.