

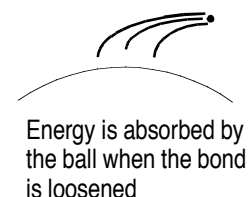
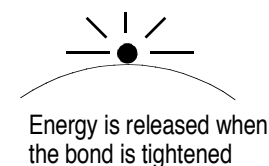
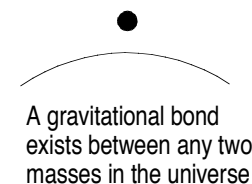
# PhyzGuide: Mass/Energy Equivalence

**CONCEPT #1: Mass and energy are different manifestations (“flavors”) of the same thing!** Mass can be thought of as “condensed energy.” This is a very heavy concept. Einstein was the first to discern the equivalence of mass and energy. The expression he derived to show this equivalence has become the most famous equation of the twentieth century:  $E = mc^2$ .

$$E = mc^2$$

Would you have to write this equation on your notesheet to remember it?

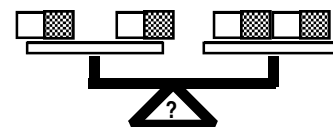
**CONCEPT #2: Energy is released whenever a bond is formed or tightened.** Consider the gravitational bond between a bowling ball and the earth. When the ball is held 2m above the surface of the earth, there is a bond of a certain strength. If the ball is released, gravitational attraction brings the two objects together: the bond is tightened. And energy is released in the form of work done to make an indentation in the ground where the ball lands and/or in the sound that emanates from the impact.



**Conversely, energy must be added to break or loosen a bond.** If the bowling ball/earth bond is to be loosened, energy must be added (absorbed by) to the bowling ball. Work can be done on it to raise it or propel it away from the earth.

**SYNTHESIS:** Consider both concepts together and answer this question:

*Which has more mass—two magnets separated by a distance, or two magnets bound to each other? There is a difference (though it may be too small to measure with our current level of technology). Hint: two magnets separated by a distance have a certain attraction for each other. If they are allowed to come together, would the bond be tightened or loosened?*



*If this is true, was energy released or absorbed when the two came together?*

What, then, is your conclusion? CAUTION: THINK!

**\_\_1. Since energy is released when the magnets come together, mass/energy equivalence indicates that the mass of the bound magnets is less than that of the unbound magnets.**

**\_\_2. Since energy is released when the magnets come together, mass/energy equivalence indicates that the mass of the bound magnets is greater than that of the unbound magnets.**

**\_\_3. Since energy must be absorbed for the magnets to come together, mass/energy equivalence indicates that the mass of the bound magnets is less than that of the unbound magnets.**

**\_\_4. Since energy must be absorbed for the magnets to come together, mass/energy equivalence indicates that the mass of the bound magnets is greater than that of the unbound magnets.**

