The operation of a rubber motor makes the AMA ALPHA an excellent example for learning about energy, particularly demonstrating potential and kinetic energy. When the rubber motor of a model plane is wound it becomes a form of stored potential energy. As the rubber band unwinds, this potential energy is converted into kinetic energy, the energy of motion. In this system, kinetic energy is expressed in the following way: the propeller spins and the air behind the propeller is pushed back. As a result, the plane moves forward. All of these are forms of motion that are the result of kinetic energy.

As the ALPHA moves forward, air molecules flow over the wings that are also a part of the plane. This airflow causes lift that causes the plane to climb. This altitude gain is itself a form of potential energy. When the rubber band completely unwinds, the altitude gained is converted back into kinetic energy in the form of distance or duration as the plane descends as a glider.

DISCUSSION POINT: In a system, energy can be expressed in many ways. Other than movement, can you think of other ways in which the ALPHA might release small amounts of energy (for example: sound, heat)?

Newton's laws and the science behind getting the best flight out of the ALPHA: Sir Isaac Newton first presented his three laws of motion in 1686. Here's how they work with flight!

Newton's 1st law states that every object remains at rest (or in uniform motion in a straight line) unless compelled to change its state by the action of an external force. In aviation, there are four forces of flight: thrust, drag, lift, and weight. The way these forces interact determines how flight happens. Imagine an aircraft cruising through the air at a constant altitude: at that point, all of the forces are balanced.

Newton's 2nd law states that the acceleration of an object is dependent upon two variables: the net force acting upon the object, and the mass of the object. The equation for this is Force = mass x acceleration. In general, planes with more turns on the rubber band motor will generate more thrust and will have a greater flight duration in the air. Planes with more turns on the rubber motor typically fly higher and farther and have longer flight times than planes with fewer turns.

Increasing the number of times the rubber band is wound typically will increase the time that the propeller will spin, increasing overall flight duration. However, students may find that increasing the number of turns in the rubber band also makes the propeller spin faster with the effect of increasing thrust, making the plane fly faster. If the plane is trimmed to fly in level flight at low speeds and increased thrust is applied, the plane will tend to climb rather than stay in level flight.

According to **Newton's 3rd law**, every force has an opposing force. For a plane to stay in level flight or climb, the thrust produced by a propeller must equal or exceed the drag produced by the shape of the plane. In a similar way, lift produced by the wing must exceed the mass of the

aircraft, expressed as weight (the force of gravity acting downward on a mass). If the lift is insufficient, the plane will descend because of the force of gravity.

Putting Newton's laws to work for your ALPHA: You can experiment with trimming the aircraft to maintain level flight or a slight climb, increasing the number of turns in the rubber motor. To maximize endurance, the ALPHA should be launched at the

- "best speed to fly"
- proper pitch

Finding the "best speed to fly":

Sufficient velocity is needed to generate lift, and this is why the propeller is needed: to generate thrust. As the plane moves through the air, lift is produced, but so is drag. Too much speed can also mean too much drag for an ideal flight. **Flight duration of the aircraft is optimized at the velocity that maximizes the production of lift while minimizing the amount of drag.** This velocity is sometimes referred to by aviators as the "best speed to fly." The speed of your ALPHA may vary from launch to landing. Note the amount of turns you put into the motor and observe your flights to determine the best speed.

Finding the proper pitch: Pitch refers to the up or down angle that the nose is pointed. This angle impacts flight:

Too much nose-up attitude: the plane will immediately climb and lose velocity. With insufficient air going over the wings to generate lift, the wing will stall, which means gravity will force the plane to descend. As it falls, the speed picks back up again and increased air-flow over the wing may help the plane level out and continue flying. However, flight duration will be reduced because of the stall.

Too much nose-down attitude: pitching the plane toward the ground means high initial velocity, but decreased flight duration. Possible damage to the model if it hits the ground too hard.

In between these extremes is the best attitude for launch! With wings level and nose pointed at the horizon, the flight should be a success.

Launching the ALPHA: Launch as if throwing a dart at a dartboard, rather than throwing a curveball. This launch method minimizes induced drag. Throwing the plane with a twist (as a curveball) creates roll and yaw, both of which can add drag.

Duration and distance are maximized when both potential and kinetic energy are conserved. For purposes of this lesson, little can be done about weight (the force of gravity acting on the mass of the plane). To counteract weight, airfoils like the ALPHA wing are designed to maximize lift. Students can study applying different amounts of thrust (the number of rubber band windings) to see how stored potential energy is converted to kinetic energy. They can also try to minimize drag by launching correctly to keep the plane from stalling or diving and being damaged. Drag is

often considered “the enemy of flight,” and this unit allows students to explore the opposing forces of thrust and drag.

For the potential/kinetic energy lab, each pair or group of students will need

- an assembled AMA ALPHA
- a ruler or measuring tape
- a stopwatch or other timing method
- student handout
- pencil or pen