Principles of Flight

Lesson Plan: Fly, Kimoto Flyer, Fly

Grade Level: 9-12

Subject Area: Science

Time Required:
Preparation: 15 minutes
Activity: 1 50-minute period

National Standards Correlation:

Science (grades 9-12)

- Science as Inquiry Standard: Understanding about scientific inquiry.
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.
- Unifying Concepts and Processes Standard: Change, constancy, measurement.
- Unifying Concepts and Processes Standard: Systems, orders, and organization.
- Unifying Concepts and Processes Standard: Evidence, models and explanation.
- Physical Science Standard: Motions and forces.
- History and Nature of Science Standard: Scientific knowledge.

Summary: Students will work in cooperative groups to build a Kimoto flyer following directions. The model will be used to discuss principles of flight and the forces acting on an airplane. Students will then use the Kimoto flyer to collect data on the force applied, the distance traveled and the time of flight.

Objectives: Students will:

- Construct a Kimoto flyer following instructions.
- Investigate the forces acting on the flyer.
- Measure the thrust force with a spring balance.
- Calculate the stored energy in the rubber band.

Materials: Each group will need:

- Kimoto Flyer pattern
- Spring balance (0-10 N)
- Styrofoam plate (10.5 in)
- 2 large paper clips
- Scissors
- Transparent tape
- Rubber band (4 in)
- Pliers (to bend paperclip)
- Meterstick or measuring tape
- Stopwatch
- Electric balance

Safety Instructions: Do not fly model planes directly at another person. Use caution when flying the models. Create a single direction flight zone. Have all students stand behind the “takeoff” line. Give an “all clear” signal when it is time to fly the planes, and do not allow students to cross the “takeoff” line to retrieve airplanes that have already landed until a “retrieve all planes” signal has been given.

Originally published as part of *Project SOAR™: Science in Ohio through Aerospace Resources, Volume I-III.* Dayton, Ohio: The National Museum of the United States Air Force and The Air Force Museum Foundation, Inc. 1997-1999.

Procedure:

A. Warm-up

1. Review potential energy (U) and kinetic energy (K).
2. Review balanced and unbalanced forces.
3. Review the four forces of flight (lift, drag, thrust and gravity).
4. Review Bernoulli’s Principle using the wing of an airplane.
5. Review the distance formula. (d=rt)
6. Review the terms Pitch, Roll, and Yaw.
7. Review the individual jobs in the group: Pilot, Timer, Measurer, Recorder

B. Activity I

Students will use the pattern to construct the Kimoto flyer.

1. Cut out the circle of the pattern.
2. Place the pattern on the bottom of an inverted styrofoam plate.
3. Tape the pattern to the plate.
4. Use a pen to score the solid and dashed lines through pattern and into the plate. Remove the pattern, cut out all solid lines, and use a ruler to score dashed lines. Make sure they are parallel.
5. Bend the centerline (main body) down and pull tail up along dashed lines.
6. Bend a large paper clip at a 90 degree angle in the first 0.5 cm. Use the open end of paperclip. This becomes a hold back fitting for launching the flyer.
7. Place the closed ends of paper clip (not bent) on the front of the airfoil so that it will fit above and below the leading edge. Tape it to the top and bottom to hold in-place and to retain slight ‘V’ shape of flyer.
8. Make rubber band catapult from large paper clip for launching purposes.
9. Launch ‘flyer’ by attaching loose end of catapult rubber band to hold back fitting on nose of the flyer. Apply tension between catapult and flyer, holding the body of the flyer (not tail) and release the flyer away from any object that it might strike.

C. Activity II

1. Do several practice launches.
2. Measure the length of the rubber band at rest (not stretched) in mm, and record the data in your Flight Log.
3. Attach the spring balance to the rubber band, and use it to launch the flyer and measure the force.

4. Pull back in a “launch ready” position with a 2.0 N force. Measure the length of the stretched rubber band in mm, and record the length and the force in the Flight Log.

5. Launch the flyer with the 2.0 N force. Use a stopwatch to measure the time of flight.

6. Measure the horizontal straight line path taken by the flyer in meters. Record data.

7. Repeat steps 2 - 6 for a total of 3 trials.

8. Repeat experiment with a 4.0 N force, a 6.0 N force and a 8.0 N force. Do three flights for each force. Record all data.

9. Mass the flyer.

D. Activity III

1. Calculate the average distance traveled and average time of flight for each force.

2. Calculate the average velocity for each force.

   Average velocity = (average distance) /(average time of flight).

3. Calculate the kinetic energy of the flyer.

   K = 1/2 mv2 where m is the mass of the flyer and v is the velocity of the flyer

4. Calculate the average force for 2.o N, 4.0 N, 6.0 N, and 8.0 N. (A better value for the force could be found. See extension.)

5. Calculate the stored energy (i.e - potential energy (U)) in the rubber band

   U = (average force)(stretch of the rubber band in meters).

6. Calculate the difference between the stored energy of the rubber band and the kinetic energy of the flyer.

   K – U

E. Wrap-up

1. Compare and contrast the length of the stretched rubber band with the velocity and distance traveled. What hypotheses can the class infer about the relationships of these three pieces of information?

2. Compare and contrast the amount of stored energy in the rubber band (U) with the force N and the velocity and distance traveled. What hypotheses can the class infer about the relationships of these three pieces of information?

3. Discuss the amount of variability in measurements in the 3 trials using the same force. What factors could have contributed to the variability of data? What was the importance of finding the average distance, time, velocity, and force?

4. Compare and contrast the average information from all the groups. Does this larger data sample increase the accuracy of the measurements?

Originally published as part of *Project SOAR™: Science in Ohio through Aerospace Resources, Volume I-III.* Dayton, Ohio: The National Museum of the United States Air Force and The Air Force Museum Foundation, Inc. 1997-1999.

5. Compare and contrast the difference in Potential and Kinetic energy produced from the rubber bands in all of the teams' experiments. What relationship exists between the potential energy and the kinetic energy? What conclusions can the class infer about the quality control of rubber bands production?

Assessment/ Evaluation: Students will be evaluated on accuracy of measurements and calculations, and participation in class discussions.

Extensions:

1. Use a spreadsheet program to construct data and calculations tables.

2. Find a better value for the force applied by using calculus and integration. The force on the length of the rubber band is not a linear function. For higher grades, you could use Hooke's Law to find the value of k in $F(x) = - kx$. for the rubber band. The value for k will not be a constant; it will be a function of x where F(x) is the spring force, x is the amount of stretch, and k is the stiffness of the rubber band. Then integrate F =dx to find the work done which is the stored potential energy of the rubber band.

3. Use different rubber bands to show the stored energy is different for different elastic bands.

Originally published as part of *Project SOAR™: Science in Ohio through Aerospace Resources, Volume I-III.* Dayton, Ohio: The National Museum of the United States Air Force and The Air Force Museum Foundation, Inc. 1997-1999.

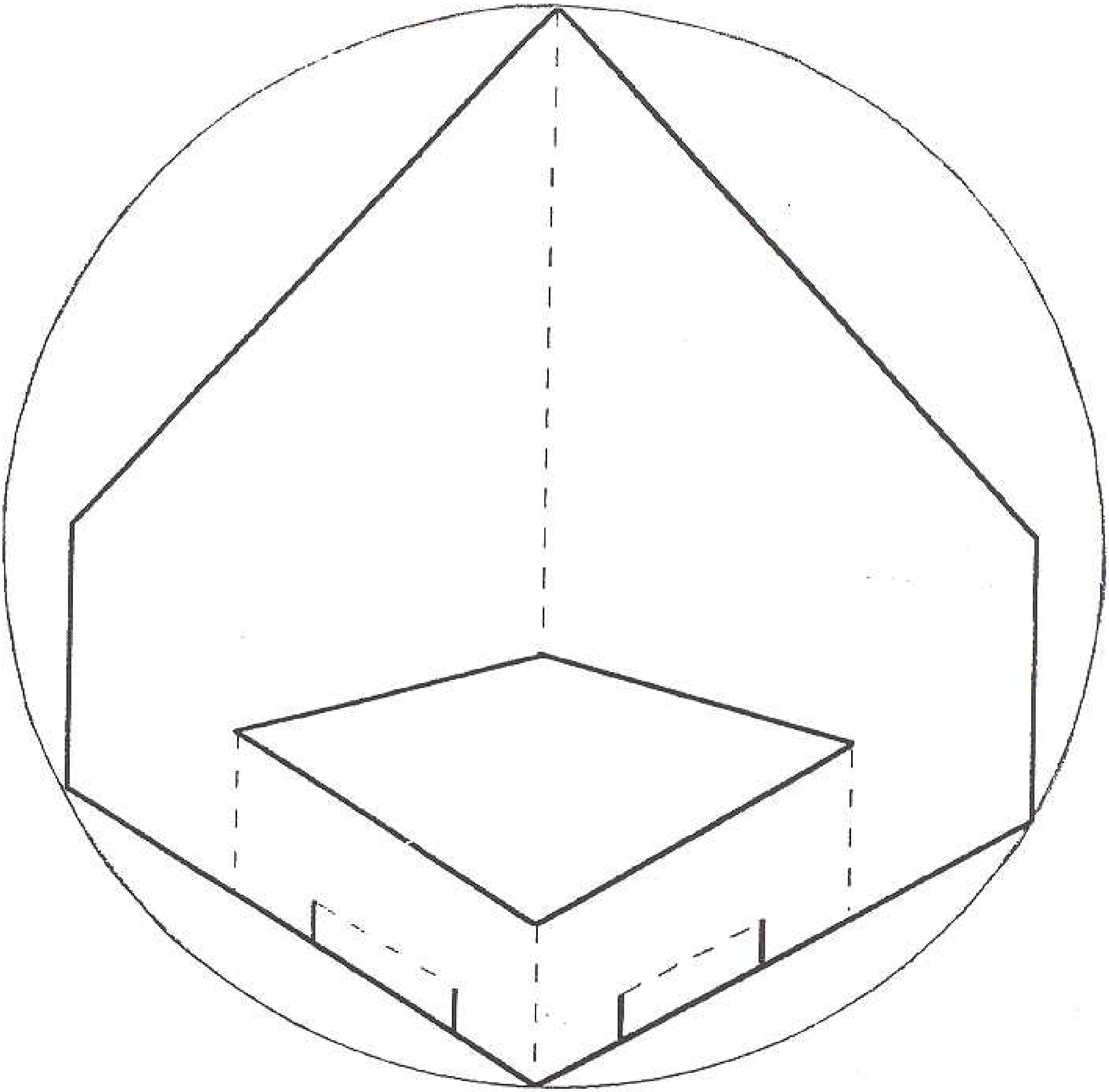
Flight Log

Mass of Flyer________________

Length of Rubber Band at Rest________________

(f) Force (N)	Length of Rubber Band (mm)	Length of Rubber Band (m)	(t) Time (sec)	(d) Distance (m)	$(\vec{v})$ Velocity (m/sec)	Avg d (m)	Avg t (sec)	Avg v (m/sec)	Avg f (N)	PE	K - U
2.0 N											
4.0 N											
6.0 N											
8.0 N											

Originally published as part of *Project SOAR™: Science in Ohio through Aerospace Resources, Volume I-III.* Dayton, Ohio: The National Museum of the United States Air Force and The Air Force Museum Foundation, Inc. 1997-1999.



KIMOTO FLYER

Directions:

1. Cut out circle of pattern.
2. Place pattern on the bottom of an inverted styrofoam plate.
3. Tape pattern to plate.
4. Score through pattern into plate the solid and dashed lines with a pen.
5. Remove pattern, cut out all solid lines, score dashed lines. Make sure they are parallel.
6. Bend center line (main body) down and pull tail up along dashed lines.
7. Bend large paper clip at a 90 degree angle in first 0.5 cm. Use the open end of paper clip. This becomes a hold back fitting for launching "Flyer".
8. Place closed ends of paper clip (not bent) on the front of the airfoil so that it will fit both above and below the leading edge. Tape it to the top and bottom to hold in-place and to retain slight "V" shape of Flyer.
9. Make rubber band catapult from large paper clip for launching purposes. (see pg. 2)
10. Launch "Flyer" by attaching loose end of catapult rubber band to hold back fitting on nose of Flyer. Apply tension between catapult and Flyer, holding the body of the Flyer (not tail) and release the Flyer away from any object that it might strike.
11. Experiment with control surfaces on the tail to tune you Flyer to perform turns or a loop.