ScienceNews

Activity Guide for Students: The Physics of Flying Seeds

Directions:
In this activity, you will discuss how natural structures inspire design solutions to engineering problems. You will define the engineering problem to be solved and will establish the criteria and constraints for the solution. Then, you will develop, test and improve models that meet the criteria and constraints to solve the problem. You will test and compare the design solutions developed by different groups. Finally, you will determine which features of the design contributed most to the successful models.

The setup
As homework, read the online *Science News* article "Whirling maple seeds inspired these tiny flying sensors" and answer the following questions.

1. What characteristics of maple seeds in flight inspired engineers to make the microfliers?

2. What benefits do the shapes of the microfliers provide?

3. What are some of the uses that scientists envision for these microfliers?

4. Research the structure of a maple seed, or samara. Draw a diagram of the maple seed and label the following structures and dimensions: seed, area of concentrated mass, center of mass, base tip, wing tip, wing, leading edge, maximum wing width (wing chord) and length of seed (span).

5. Why do maple seeds spin as they fall?

6. Study the photograph of the microfliers in the article. How would you describe the shapes of the microfliers? What do the microfliers have in common with each other and with the maple seed you drew?

Class period 1
Defining the design problem
As a class, you will define the engineering problem to be solved and will establish the criteria and constraints for the solution. Criteria are the requirements that a solution needs to meet for the solution to be successful. Criteria commonly refer to specifications that the object or process must include, or it

cannot perform the needed function. Constraints are limitations to the solution or to the implementation of the solution.

You will use the problem statement and the criteria and constraints to design a flier that mimics natural seed structures. You will use these fliers to determine which combinations of structures are most beneficial for dispersing seeds. To prepare for the engineering design activity, discuss and answer the following questions as a class.

1. Define the engineering problem that needs to be solved.

2. What are the requirements that the model needs to meet to be successful?

3. What are the limitations or constraints on the model?

4. How has the problem already been solved by plants?

Develop possible solutions
After the class has defined the problem and established criteria and constraints for design solutions, work with your group to develop and refine a design for a flier. Use the following questions to guide your design development.

1. What scientific principles are going to guide your design?

2. What features could you build into your flier? Brainstorm ideas for how to construct a flier that meets the criteria and constraints determined by the class. Record all ideas as they are presented and build on the ideas of others.

3. Which design idea has the most potential for success? Use the criteria and constraints developed by the class and the research about how seeds glide to compare ideas.

4. Select one solution for your group to model. What materials do you need? How will you join the components together?

Class period 2

Test and refine your solution

Use the following questions to guide the construction of a model of your design. Use the materials provided by your teacher and follow the criteria and constraints established by the class. Use caution when cutting materials, applying adhesives and when testing your models.

1. Construct a model of your design. Record the materials you used, the mass, length, diameter, angles of the wings and other relevant details of your design.

2. Test your model by releasing it from a selected height. Time how long the flier falls between when it is dropped and when it touches the floor. Measure the distance the flier travels from the point on the floor directly beneath the point of release. Perform the drop three times and record the results of each trial.

3. Review the results of your test. How well did your model meet the criteria?

4. Discuss how you could make improvements to your design. Try asking the following questions as you analyze your design.

What about the design worked?
Why was that element successful?
What function did the element serve?
Can you improve on that element in your design?
What about the design didn't work?
What function did that element serve?
Why wasn't that element successful?
How did that element detract from the overall design?
Can you improve on that element in your design?
How could you modify the existing design to improve your model's performance?

5. Choose one element to change in your design. Describe the change you will make and why you chose that element to change. Build a new model using your revised design.

6. Test your new model. Record how the new model performed.

7. How did the change you made to your design affected your model's performance? Why do you think you got that result?

8. Discuss how you could make improvements to your design. Ask the same questions you used the first time you analyzed your design. Will you build a modified model based on your first design or your second design?

9. Construct and test a new model based on your design review. How did the new model perform?

10. Repeat the testing and redesigning process as many times as needed within the class period until you have optimized your design. How many models did you build? Record all the changes to the design as you make them.

11. Construct your final model and store it as directed by your teacher. This is the model you will use to compete with the other fliers constructed by other groups.

Class period 3
Check and refine your final design
With your group, prepare to test your design against the models developed by other groups. Answer the following questions as you check and prepare your model for testing.

1. Review your model. Compare it to the criteria and constraints. Is your model complete and ready to test? Describe any adjustments you need to make to your design to prepare your model for testing.

2. Make any necessary changes to your design. Record the materials you used, the mass, length, diameter, angles of the wings and other relevant details of your final design.

Test and compare models
As a class, use the apparatus set up by your teacher to test and compare the distance traveled by each model. Record the data from each test as directed.

1. Construct a data table to record the information about the group models. Make sure you include information about the models that will allow you to compare their designs after the testing is completed.

2. Each group should test its model three times following the procedure described by your teacher. Record the results of each trial in a data table that records the trial number, the distance traveled and the falling time of each model.

Analyze the results
After testing is complete, analyze the results of the test as a class and discuss the answers to the following questions.

1. Analyze the data you recorded for each trial. Which model performed the best? How did you determine this model performed the best?

2. What structures optimized the performance of the best model?

3. In what way could the quantitative data be displayed visually to correlate the models' structures with distance traveled?

4. Imagine that you could influence the shape of maple seeds through genetic engineering. What seed structures or features would you modify to increase the distance that it can be dispersed by wind?

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