Steep Fire, Flat Fire

Time: 30 minutes for activity, 20 minutes of inquiry and data collection.

Materials:

three sticks of non-combustible kid's clay (not modeling clay, it combusts)
large strike-on-box stick matches (the little box matches do not work)
spray water bottle
metal tray
stopwatch
book or objects to angle the tray.
The results vary depending on the type of matches used. Strike anywhere matches are more dramatic. Make sure the matches have not been exposed to moisture.

Introduction

When referring to a wildland fire, conduction is the physical spread of a flame—the blade of grass burns and lights the blade next to it. Radiation from the heat of those two blades dries out a mountain mahogany and a spark catches it on fire.

Note to teacher: Before starting this activity ask if lighting multiple matches will set off the fire alarm. If yes, then move outdoors. If you are not in a science lab, let your administration know what you are doing. More than eight matches, in close proximity to each other, burning at once will set off most fire alarms. If indoors, know the location of the nearest fire extinguisher. *Use a match to light the first match in the demonstration, and put it out right away, save the match or put it in a conspicuous place. If students do not observe the saved match you will have to point it out to them.*

Directions

Preface this activity by tell the students that the matches represent trees.
(If time is short, prep steps 5-7)

1. Fill the spray bottle with water and place it close to the work space.
2. Designate someone to run the stopwatch.
3. Designate someone to record the official data to share with the class.
4. Have anyone with long hair, including spectators, tie it back.
5. Stick three matches in a clump (touching) in a stick of clay. Evenly space five more matches starting an inch away from the clump. Space the rest a half an inch apart.
6. Put eight matches in a straight line in the second stick of clay. Space them about a half of an inch apart. Do the same for the third stick of clay.
7. Place all three in the metal tray.
8. Let the students know you will be angling the tray (45 degrees) for the third burn.

9. Have the students, one per science notebook page, write or draw the three arrangements of matches.
10. Ask the students to write down their predictions of what will happen with each set of matches.
11. Light the clump of matches on the first strip of clay.
a. Start the stopwatch when the first match is lit. (Put out the match used to light the demonstration matches.)
b. Let the demonstration burn out.
c. Stop the timer when the active burning is complete.
d. Document the time.
12. Light the first match in the straight line of matches on the second strip of clay.
a. Start the stopwatch when you light the first match in the row, do not light the rest.
b. Allow those that burn to burn out.
c. Stop the timer when the active burning is complete.
d. Document the time.
13. Tilt the tray to a 45 degree angle, and then light the first match in the straight line of matches on the third strip of clay.
a. Start the stopwatch when you light the first match.
b. Let it burn.
c. Stop the timer when the active burning is complete.
d. Document the time.
14. Spray all of the matches with water to cool off.
15. Have the students draw the results.
16. Have the students compare their prediction to the results.

Teachers note:
What you should see:

- First strip of clay – The clump of matches should all ignite, the next match in line may or may not light (depends on air currents), but none of the others should.
- Second strip of clay – The first match you light and perhaps the second match will burn. The second match in line may or may not light (depends on air currents) from the radiant heat from the match you used to light the first match. There will not be enough radiant heat to light the third match.
- Third strip of clay on a slope – The fire should spread to all the matches after the first one is lit.

Extension
If there is sufficient time and materials, set up several more clay strips with matches in the same formation as with the third tray. Start by angling the tray 15 degrees, light the first match, and record burn pattern and speed. Repeat the process several more times with the different clay strips, but increase the angle of the slope by about 15 degrees each time. Observe the effect of increasing slope on burn pattern and speed.

Results Explanation

When the clump of matches burned on the first strip, the fire was conducted to the other matches. The line of matches displayed a transfer of heat through radiation. The line of matches on a 'slope' displayed a transfer of heat energy through convection and radiation. The matches are not physically touching, so conduction is not a factor in the last two demonstrations.

Science Notebook Questions: Have the students answer these questions for each demonstration.

Q1) What percent of the matches burned?

$$\frac{\text{is}}{\text{of}} = \frac{\%}{100} \text{ or } \frac{\text{part}}{\text{whole}} = \frac{\%}{100}$$

Percentage formula

Q2) What is the relationship between the percent of matches burned and the match configuration?

Q3) What method or methods of energy transfer was used to ignite the other matches?

Q4) How could you alter the arrangement of matches in model two, the straight flat line of matches, to demonstrate conduction? Radiation?

Q5) How does slope affect convection?

Q6) Is there a correlation between the time it took to burn and the depth of the burn (severity)?

Science Notebook Answers

Q1) What percent of the matches burned?

$$\frac{\text{is}}{\text{of}} = \frac{\%}{100} \text{ or } \frac{\text{part}}{\text{whole}} = \frac{\%}{100}$$

Percentage formula

A) strip #1: ~37.5 % if just the clump burns. Strip #2: ~12.5 %. Strip #3: Can be 100%.

Q2) What is the relationship between the percent of matches burned and the match configuration?

A) As distance between matches decreases, percent burn increases. As slope increases, percent burn increases. Slope is one of the most important variables. In general, the steeper the slope,

the greater the fire severity. Radiation and convection team up to have devastating results on forest burn severity and home destruction. Clumps sometimes may go unnoticed. Have students equate the dense forest conditions of today with the clump burn and the reality of slopes in Colorado.

Q3) What method or methods of energy transfer were used to ignite the other matches?
A) The touching matches demonstrate conduction. The spaced, flat matches demonstrate radiation and appropriate tree spacing on a flat slope (but keep in mind that natural terrain has hills and contours). The slope demonstrates convection and radiation.

Q4) How could you alter the arrangement of matches in model two, the straight flat line of matches, to demonstrate conduction? Radiation? Convection?
A) Conduction would have all the matches touching, radiation would have the matches placed closer together, and convection would require creating a slope.

Q5) How does slope affect convection?
A) Convection is the rising of hot air, which preheats a fuel before the spark. A slope channels the convection column in the angle of the slope- the greater the slope the greater the concentration of heat. This heat 'preheats' the fuel upslope.

Q6) Is there a correlation between the time it took to burn and the depth of the burn (severity)?
A) A fast burn - one that moves through an area and then quickly goes out - usually does not have time to do more than scorch. Show students the match you used to light the demonstrations with (you put it out as soon as the first match was lit). Compare it to the single match lit in the flat row of matches. The students should be able to draw a conclusion that the amount of fuel (fuel loading) represented by the clump of matches has a direct correlation to the depth of burn.