Name:________________________________Section:__________________________Date:__________________

CONCEPTUAL **Physics**

Free Fall and Air Friction

Activity

What a Drag!

Purpose

To investigate how the terminal speed and weight of an object are related.

Equipment and Supplies

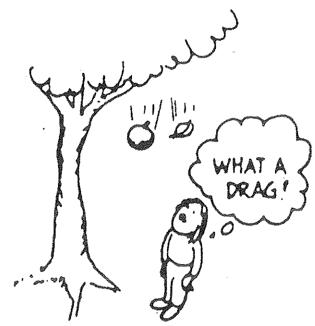
coffee filters (basket type—not V-shaped), large and small
meterstick
two-meterstick or two single metersticks taped together

Discussion

Drop a feather. It accelerates, but its large area-to-weight ratio causes it to quickly reach *terminal speed*. Common paper coffee filters demonstrate this nicely, since they have a large area-to-weight ratio. Drop a couple of filters simultaneously from the same height and they fall together. Drop a single filter and a double-weight filter—two stuck together—and the heavier one hits the floor first. For this case, is air resistance proportional to speed, or to the square of the speed? We can find out by seeing how much higher a twice-as-heavy filter should be dropped to reach the floor at the same time as a dropped single filter.

At terminal speed, v_T, the air resistance equals the weight of the falling object, and the distance fallen is

$$d = v_T t$$



First Hypothesis

Air resistance is proportional to the speed ($R \sim v$).

If resistance $R \sim v$, then $v_T \sim W$. Then the falling distance

$$d \sim Wt$$

It follows that the double filter of weight $2W$ will fall $2d$ in the same time, a triple filter of weight $3W$ will fall $3d$ in the same time, etc.

Procedure-I

If a single filter is dropped from rest 1 meter above the floor and at the same time a double filter is dropped 2 meters above the floor, and they land at the same time, then the hypothesis $R \sim v$ is confirmed.

Drop the filters and see. Do they hit the floor at the same time? Record your observations.

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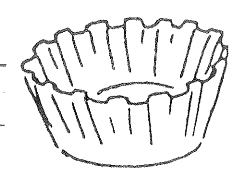


Second Hypothesis

Air resistance is proportional to the speed squared ($R \sim v^2$).

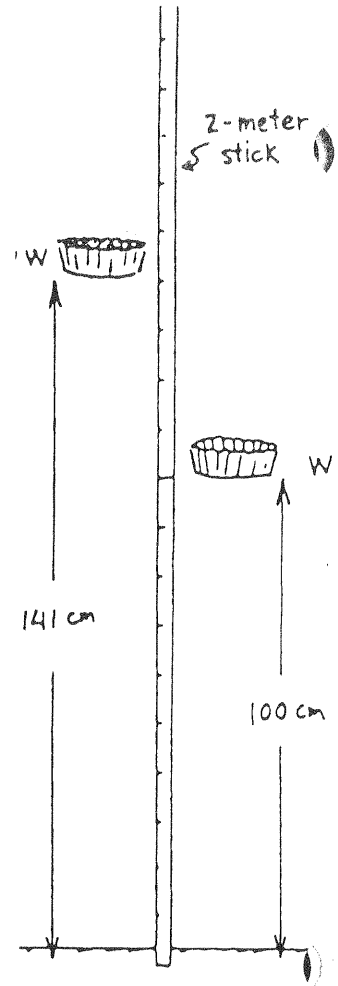
If $R \sim v^2$, then $R \sim W \sim v^2$. Then $v \sim \sqrt{W}$, and

$$d \sim \sqrt{W}\, t$$

whereas for two filters, the weight $2W$

$$D \sim \sqrt{2W}\, t \sim \sqrt{2}\sqrt{W}t \sim 1.41\, d$$

Now drop a single filter from 1 meter above the floor and at the same time drop the double filter 1.41 meters from the floor. If they land at the same time, the hypothesis $R \sim v^2$ is confirmed.



Procedure-II

Simultaneously drop the single and the double filter. From what heights will they hit the floor at the same time? What is your conclusion? Test it by simultaneously dropping four nested filters 2 meters high and a single filter one meter high.

Analysis

1. What model of friction is confirmed by your experiment?

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2. How does air friction vary with speed?

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3. How does this experiment help explain how a parachute works?

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Going Further

Predict what height three filters nested together should be dropped so that they hit the floor the same time as a single filter dropped from a height of one meter. Try it and see! Record your results.

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