Will You Get Wetter if You Run Rather than Walk in the Rain?

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Introduction

If it is raining, will you get wetter if you run to shelter rather than walk? Does it matter if you run or walk to shelter? It turns out the answer depends on whether the rain is falling straight down or diagonally, and if diagonally, whether it is coming toward you or from behind you as you move toward shelter. The following paragraphs provide three different explanations, two conceptual and one mathematical. The two conceptual explanation apply to the situation when the rain is falling straight down. The mathematical explanation will apply in all circumstances.

Two Conceptual Explanations

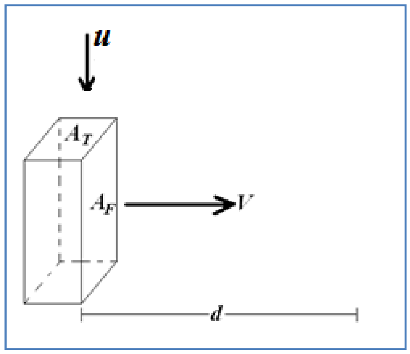
Explanation #1: Just imagine that you and a friend are each are holding a sponge in the palm of your hands, while it is raining. The rain is falling straight down. You are 100 meters from shelter. Your friend is wearing rocket propelled roller skates that whisks him to shelter in 2 seconds. You decide to walk very slowly, and it takes you ten minutes to get to shelter. Whose sponge do you think will be wetter? Your sponge has been exposed to rain for 10 minutes, while your friend's sponge was exposed to rain for 2 seconds. It should be obvious that your sponge will be wetter than your friend's.

Explanation #2: Imagine instead that you and your friend are carrying buckets instead of sponges. Your bucket has been exposed to rain for 10 minutes, while your friend's bucket has been exposed to rain for 2 seconds. Again, it should be obvious that your bucket will contain more water than your friend's.

A Mathematical Explanation

If the above two simple thought experiments haven't convinced you that by running you will be less wet, then let's apply some simple math to the problem.

Explanation #3: The figure below shows a rectangular sponge moving at a speed V toward the right. Raindrops are falling straight down at a speed u. The area of the top surface of the sponge is A_T, while the area of the front of the sponge is A_F. The total number of raindrops per unit volume of air (number density) is n, and is assumed to be constant.



The rate of raindrops being absorbed into the sponge through the top (number of drops per second) is given as

$$R_T = nuA_T \,. \tag{1}$$

Notice that this is independent of the forward speed of the sponge. Similarly, the rate of raindrops being absorbed into the front of the sponge is

$$R_F = nVA_F \,. \tag{2}$$

The rate of absorption through the front of the sponge depends on the speed of the sponge, and as speed increases, this rate increases. If you think too quickly, you will conclude that it therefore pays to walk slowly, so the rate of absorption is less and you will stay drier. But, the slower you walk to shelter, the longer you are exposed to the flux of drops into front of the sponge. To see whether speed really makes a difference in how wet you will be once you reach shelter, we need to figure out how many drops will enter the sponge during the time it takes to get to shelter. If the distance to shelter is *d*, then the time it takes to get to shelter is

$$t = d/V \,.$$

The total number of drops entering the sponge during this time (denoted as *N*) is

$$N = \left(nuA_T + nVA_F\right)\left(d/V\right)$$

or

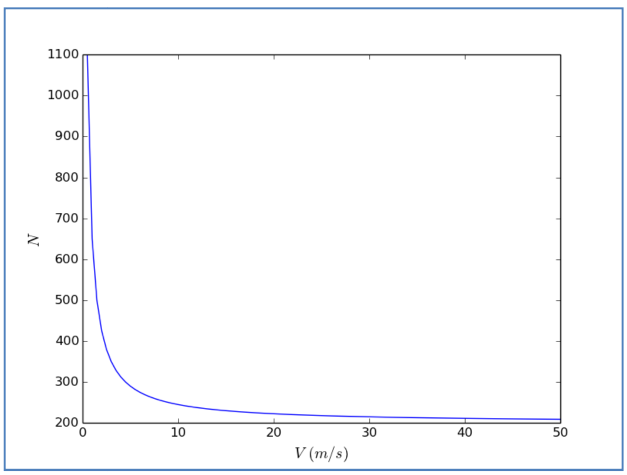
$$N = \underbrace{\frac{nuA_T d}{V}}_{Term\,A} + \underbrace{nA_F d}_{Term\,B} \tag{3}$$

The first term (*Term A*) is the number of drops that enter through the top of the sponge, while the second term (*Term B*) is the number of drops that enter through the front of the sponge. There are two important points to note:

(1) *The total number of drops entering the front of the sponge doesn't depend at all on the speed of the sponge*!

(2) The total number of drops entering the top of the sponge is inversely proportional to the speed of the sponge. *The slower the sponge is moving, the more drops enter the top of the sponge*.

So far we have shown that the quicker you reach shelter, the fewer total raindrops will strike you. We also see that your speed won't affect the total number of drops that hit you from the front, though it will affect the *rate* at which the raindrops strike you from the front; but, by moving faster you reach shelter more quickly, so even though the *rate* the drops strike your front increases, the *total number* of drops that strike you from the front is the same, no matter how fast you move. The analysis also shows that speed is very important for determining the total number of drops that strike you from above. The more slowly you move to shelter, the longer you are exposed to droplets striking you from above, and therefore, you will get wetter if you go slower. The graph below shows a plot of Equation (3) for the following values: $u = 9$ m/s, $n = 100$ drops/m^3, $d = 100$ m, $A_T = 0.005$ m^2, and $A_F = 0.02$ m^2. This plot shows that the faster you move, the fewer total drops that will strike you.



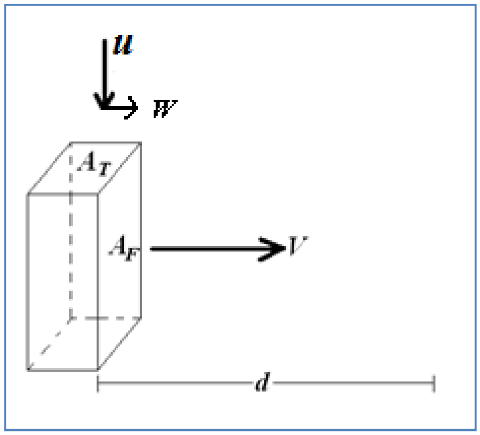
The analysis we have done is for a rectangular sponge, but the results would apply to objects of arbitrary shape. You would just have to calculate their effective frontal and top cross sectional areas and use these for A_F and A_T respectively. So the conclusions would apply to a human, animal, any other object that will absorb the drops.

If you have a barrier that prevents the drops striking from above from absorbing, then *Term A* is eliminated, and then it truly doesn't matter if you run or walk. You would get just as wet either way (this is analogous to covering the bucket in Explanation #2, since this would prevent water from entering the bucket.)

What if the Rain is Falling Diagonally?

If the rain is coming down at an angle due to a wind speed of W, then instead of using just V to calculate the rate at which drops are absorbed through the front of the sponge, we must use the speed of the drops relative to the sponge, which is

$$V_r = V - W \, .$$



and the rate through the front of the sponge is

$$R_F = n\left(V - W\right) A_F \ .$$

Note that a tail wind will decrease the flux of drops through the front, while a head wind would increase the flux (W is negative for a head wind). If W is positive and greater than V, then the flux through the front is negative. Physically, this means the drops are hitting the rear of the sponge rather than the front, and would still make the sponge wet. To account for all cases, we can speak of a flux through either the front or back of the sponge, and write the rate of absorption as

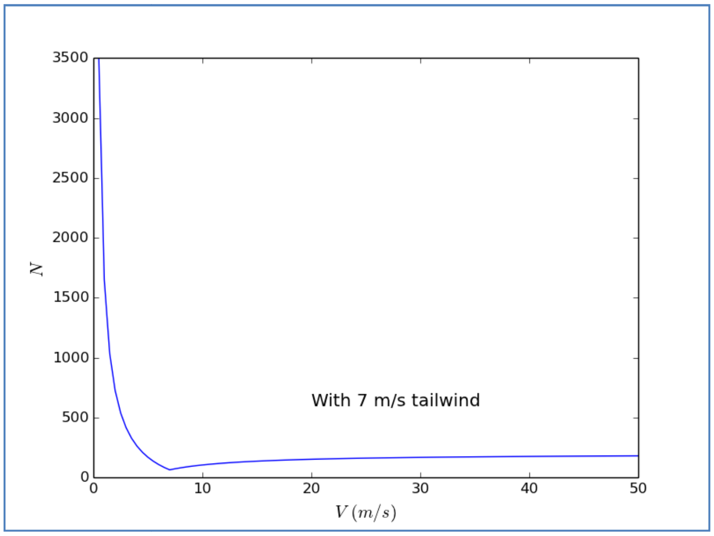
$$R_{\mathrm{For}B} = n\left|V - W\right| A_F$$

where we have used the absolute value of the difference between V and W. The equation for the total number of drops striking over a distance d is then

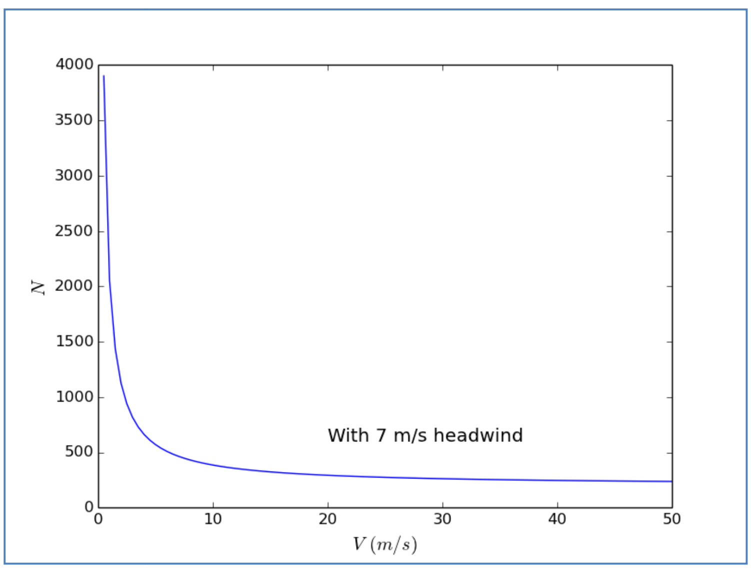
$$N = \underbrace{\frac{nuA_T d}{V}}_{Term\ A} \quad + \quad \underbrace{nA_F d \frac{\left|V - W\right|}{V}}_{Term\ B} \, . \qquad (4)$$

As before, *Term A* is the number of drops that enter through the top of the sponge, while *Term B* is the number of drops that enter through the front or back of the sponge. If W is zero we recover Equation (3). We also recover Equation (3) if the speed of the sponge is much larger than the wind speed. We also note that if you move with the wind speed ($V = W$) then *Term B* disappears, and the only flux would be through the top of the sponge.

The figure below shows a plot of Equation (4) using the same parameters as for the previous plot, only including a tail wind of 7 m/s. Note that you will stay driest if you move toward shelter at a speed equal to that of the wind.



If you have a head wind when you are running for shelter, things are different. In that case, *W* is negative, and there is no speed *V* for which *Term B* disappears. In that case, the plot of Equation (4) looks like that below. This is similar to the case of no wind in that your best bet is to move as fast as you can to shelter.



Conclusion

We have demonstrated that in order to remain driest while seeking shelter from the rain, that if you have either calm winds or a head wind, you should move as quickly as possible toward the shelter. If you have a tail wind, then you can minimize your wetness by moving toward shelter at the same speed as the tailwind. Better yet…bring an umbrella!