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P1_9 Can a Ladybird Stand on Water?

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Abstract

In this paper we investigated whether, due to the surface tension of water, a ladybird would be able to hold itself up on top of a still pond and calculated the contact angle between the end of the ladybird's leg and the water. By using the definition of force from surface tension, we have determined that the ladybird can stand on the water, with a contact angle of 69° (2 s.f).

Introduction

In nature, insects including Mosquitoes, Water Striders and Fishing Spiders are able to walk on water [1]. However, not much research has been conducted on whether ladybirds can hold themselves up on water. In this investigation, we aim to investigate whether a ladybird can stand on water by determining if there is a viable contact angle between the end of the ladybird's leg and the water.

Figure 1: A photograph of an insect standing on water [2].

We have estimated that the radius of the end of a ladybird's leg is 2.0 x 10^{-4} m. This estimation has been based on the mass to size ratio of known insects. The average mass of a ladybird is 2.0 x 10^{-5} kg [3] (2 s.f) and the surface tension of water is 0.073 N/m [4] (2 s.f).

Theory

Surface tension causes a liquid to act like a stretched elastic membrane and depends mainly upon the forces of attraction between particles within the liquid and the gas, liquids, or solids in contact with it. It is commonly observed in small droplets of liquid and soap bubbles and is the phenomenon which explains why insects can stand on water [5]. Cohesive forces between liquid molecules at a greater depth are shared between neighbouring atoms. However, molecules on the surface have stronger attractive forces because they only share these forces with their nearest neighbours. This increase in intermolecular attractive forces between atoms at the surface is what causes surface tension [6]. Also, the contact angle is defined as the angle measured in between where a solid meets a liquid surface.

The force from the surface tension can be defined as,

$$F_{ST} = \gamma L cos\theta \qquad (1)$$

where F_{ST} is the force from the surface tension, γ is the surface tension, L is the circumference of the end of the ladybird's leg and θ is the contact angle.

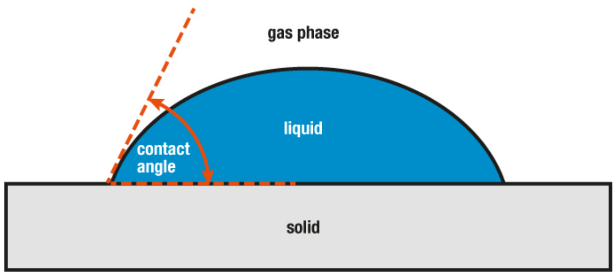

Figure 2: Diagram showing an example contact angle of a water droplet [7].

Method

In this investigation, the force from the surface tension (F_{ST}) is the ladybird's mass multiplied by gravitational acceleration due to Earth's gravity, 9.8 ms^{-2} (2 s.f.). We substituted this value for the force from the surface tension into equation 1. We have assumed that the end of the ladybird's leg is circular and that the length in equation 1 is the total of the circumference of the end of all six of the ladybird's legs. We have assumed the ladybird's leg is circular as there is insufficient available data and on observation a circular model is acceptable. We found the circumference using our estimated radius of 2.0 x 10^{-4} m (2 s.f). We rearranged the equation for the contact angle (θ) to see if it would result in a value that was a real number. If there was a real value for the contact angle then we could determine that the ladybird could stand on water. We found that the contact angle was 69° (2 s.f) between the end of the ladybird's leg and the water, so we concluded that the ladybird could stand on the water.

Discussion

We were successful in calculating an approximate estimate for the contact angle for the ladybird, but there are limitations to this investigation. We could not find a measured value for the radius of the end of the ladybird's leg. This is most likely due to it being a very obscure measurement and very difficult to measure in reality. In addition, it is very unlikely that the end of the ladybird's leg is perfectly circular. Also, we have assumed the ladybird is standing on a still pond and have not taken account any ripples or movement of the water. Finally, whether a ladybird can bend its leg at 69° (2 s.f) is up for discussion.

Conclusion

In this investigation, we found that a ladybird could stand on a still body of water, with a contact angle between the end of its leg and the water of 69° (2 s.f). Future research could look into whether this conclusion is true for all ladybirds of different species and sizes.

References

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