Does the Sand in an Hourglass Fall at a Constant Rate?

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What is the weight of an hourglass while the sand in it is falling (ignoring transient effects at the beginning and end of the flow of the sand)?

The consensus [1]-[4], based on observation, is that the weight of the hourglass while the sand is falling is slightly greater than the weight when all the sand is at its bottom, although this effect is so small that only very precise experiments can observe it.[1]

The portion of the sand that is in free fall does not contribute to the observed weight of the hourlgass, so the weight of the hourglass while the sand is falling could be less.

The sand in an hourglass is, in effect, a fluid with very large "molecules", so we expect that the pressure at the orifice of the hourglass decreases with time as the sand passes through the orifice.[2] This implies that the rate of flow of sand through the orifice decreases with time. Because the rate of falling sand decreases with time, the contribution to the weight of the hourglass at time t due to the sand hitting the bottom of the hourglass is greater than loss of weight due to the flow of sand out of the orifice at this time. Hence, this effect implies an increase in the observed weight of the hourglass when the sand is falling.

Another effect is that when the sand hits the bottom of the hourglass and comes to rest, its impact exerts a downward force on the hourglass, which increases its observed weight.

Of these three effects, it is likely that the third, impact of the falling sand, is the largest, and the observed weight of the hourglass when the sand is falling is greater than when the sand is all at the bottom.

This is the consensus view, which is reinforced by an experiment in the amusing video https://youtu.be/sVzqEn_qyFM?si=wsON1j0fgEi3G_Ob.

A counterintuitive consequence is that while the sand is falling, and the center of mass of the hourglass falls (relative to the frame of the hourglass), the center of mass of the hourglass (not counting the sand in free fall) is accelerating upwards, as emphasized in [2].

An extreme scenario is that only one grain of sand is in free fall inside the hourglass at any time. Then, the observed weight of the hourglass is less than its initial value by the weight of a grain of sand while the grain is falling, but jumps up briefly when the grain hits the bottom of the hourglass, and then quickly drops back down to the initial value of the weight until the next grain starts to fall and the cycle repeats.

The author was alerted to this issue by Derek Abbott.

[1] However, [5, 6] claim that the weight remains the same, while [7] seems to imply that the weight is less. A design of an hourglass such that its weight remains constant with time as the sand falls is given in [8]. *Apr. 21, 2026.* It was claimed in [1] that if an hourglass is filled with water (+ sand) rather than air, its weight does not change as the sand falls.

[2] *Apr. 21, 2026.* In extreme cases, the upward flow of air through the "waist" of the hourglass is important [9].

References

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