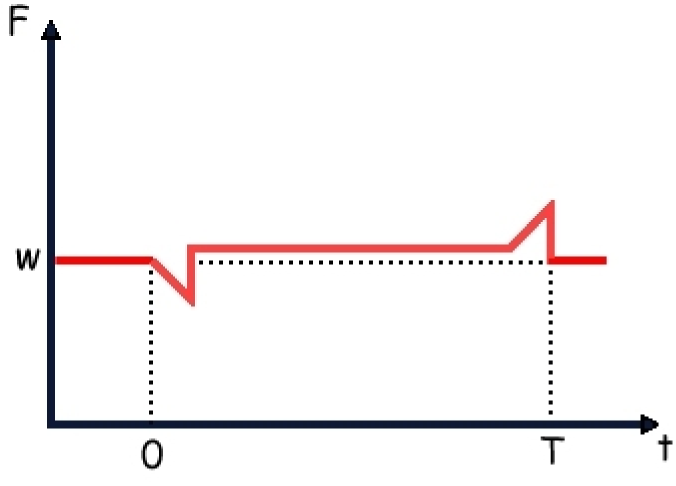
Answer #67

The answer is (a): the reading of the scale is slightly higher during the time when the sand is running than it is in the steady state, either before time t=0 or after t=T. This can be seen on an mpeg video by clicking on the photograph below.

Because the effect is very small we have used an electronic balance to carry out this measurement, where we zeroed the balance before starting the sand into motion. Although the balance varies as the sand falls, it is clear that the "weight" of the system is greater during the period in which the sand is falling. With this measurement system the weight also clearly decreases immediately after t=0 and increases just before t=T; the video is stopped during the time when just before t=T. The graph of the weight of the hourglass on the scale from before t=0 until after t=T therefore looks something like the figure below, if we do not quibble about the shape of the diagonal sections of the red line representing the weight of the hourglass.



During the time when the sand is falling, the gravitational force is pulling the sand downward. The reason why it does not fall faster is that there is only a small hole in the bottom of the upper chamber, so the sand is being held up by the sides of the hole, preventing it from moving faster. The reaction force of the sand on the sides of the funnel adds to the weight of the hourglass, increasing the magnitude of the downward force on the scale while the sand is falling. An interesting paper, by Shen and Scott, discussing this effect is given in the reference list linked to the demonstration description on the Question of the Week Main Page.

Archive 4

Question of the Week

Outreach Index Page

Lecture-Demonstration Home Page

For questions and comments regarding the *Question of the Week* contact
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