Free Fall

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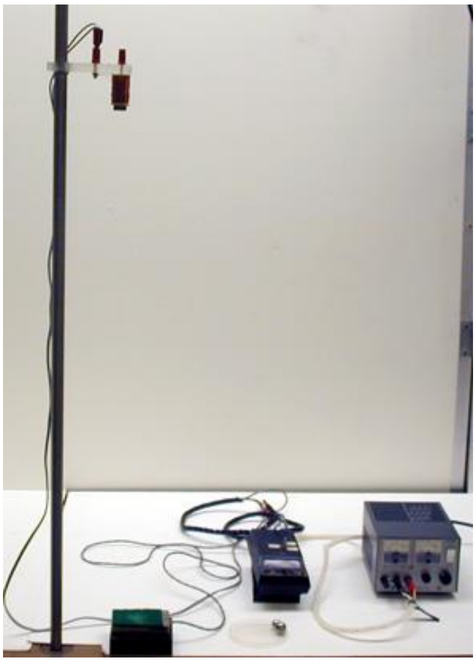
Why: We wish to test the consequence of the Equivalence Principle that all objects free fall with the same acceleration.

What: We will measure free-fall distances and times from various drop heights and with balls of different mass in order to calculate the acceleration due to gravity in each case.

How: We use the Behr free-fall apparatus, consisting of a clamp at the top of a vertical rod that releases a ball bearing, starting a timer, and a timer pad on the floor (or table) that stops the timer when the ball bearing hits.



Equipment

Behr free fall apparatus (metal rod, rod clamps, ball bearing clamp, timer, DC transformer, timer pad), one small one large ball bearing, balance, 2-meter or meter ruler.

Procedure

1. Measure the masses of the large and small ball bearings using the balance (don't forget to subtract the mass of the container).
2. Supply electrical power to the timer and turn it on.
3. Load the small ball bearing in the clamp at the top of the Behr freefall apparatus. It is critical that you perform this operation **gently** so that you do not alter the height of the clamp from one trial to the next.
4. Measure the height *d* from the bottom of the ball bearing to the timer pad on the floor using the two-meter stick. Do this more than once independently and average the results.
5. Reset the timer.
6. Release the ball bearing. The timer will begin counting thousandths of a second, and will stop when the ball bearing strikes the pad on the floor. Record the freefall time *t*.

7. Reload the ball bearing, reset the timer, and repeat for at least 5 trials, averaging the results.

8. Repeat the above steps for the larger ball bearing.

9. Move the clamp to approximately half the previous height, measure the new height, and repeat the free fall measurements for the small ball bearing.

10. Using the larger height and your average time values, for both the large and small ball calculate the acceleration *g* from the Galileo's formula

$$g = 2\ d\ /\ t^2$$

11. Use the longest and shortest times *t* you recorded to calculate a lower and upper value of *g* for each ball, and hence quote your *g* values as average ± uncertainty.

Conclusions

Write a paragraph summarizing the key things you *learnt from your data*, quoting data to support your conclusions. For example, you could discuss:

- Comparing the timing results with the small ball bearing at the two different heights, what can you deduce qualitatively about the speed of the ball as it falls?
- Is your free-fall acceleration value consistent with the standard value 9.80 m/s^2 ± 0.01 m/s^2; in other words, does the uncertainty range on one overlap with that of the other?
- Are your free-fall acceleration values for different inertial masses consistent with one another; in other words, do their uncertainty ranges overlap?
- Based on your everyday experience of falling objects, how might you expect air resistance to affect your results for g compared to true fall?