

Newton's Bucket Challenge

Abstract: In 1687 Newton's Bucket tested an application of Newton's laws in separate reference frames. The choices of frame were the Lab|Earth and the Bucket, the law to test was centrifugal force $F_c = m\omega^2$, the test object was the water in the bucket. The measured ω in the lab frame predicts F_c , but the water at rest in the bucket frame predicts $F_c = 0$.

In predicting the actual centrifugal force on a test object(water)....

- 1) the **lab reference frame was correct.**
- 2) the **bucket frame was incorrect.**

Consider this challenge: **a generalization of Newton's Bucket.**

Given:

- 1) Two ref frames in relative motion: the ECEF or Lab ref frame; the other non-Lab frame called the Test frame

Eg: Newton's laboratory and the bucket.

- 2) An object of mass m in motion relative to both ref frames.

Eg: the water

Define:

reference frame: a coordinate system with ruler, clock and data collector/observer at the origin.

law of physics: any solution of the Euler-Lagrange equations, derived from the action variational principle.

inertial frame: reference frame in which the laws of physics are valid; measured motion agrees with physical law prediction.

lab frame(ECEF): reference frame in which the lab is at absolute rest, neither translating nor rotating

test frame: any reference frame moving relative to the lab frame.

kinematics: measurement and description of motion.

dynamics: prediction of future motion using the laws of physics.

The challenge:

Apply any law of physics to the moving mass in both lab and test frames, to prove the

two Null Hypotheses:

For any physical law:

- 1) **Test frame predictions match observations.**
- 2) **Lab frame predictions don't match observations.**

If both Null Hypotheses are false...

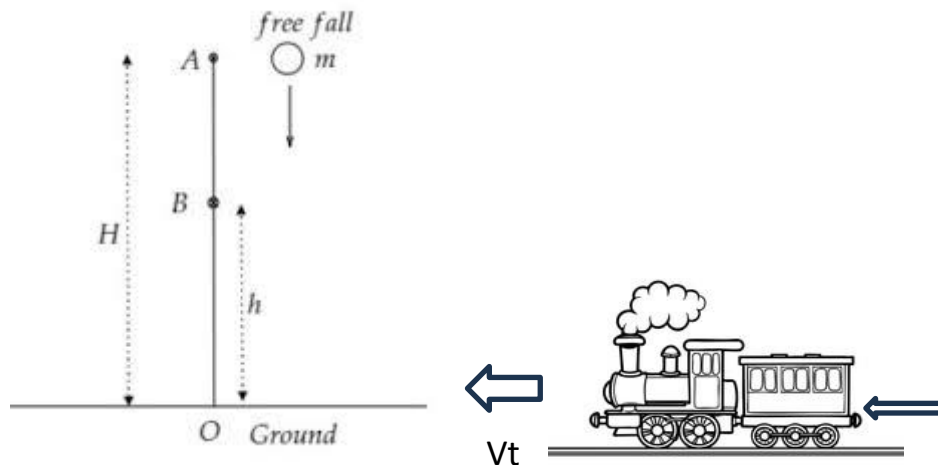
**1)Test frame predictions are invalid
and**

2) Lab frame predictions are valid.

Example of Physical law: $E = T + V$ Conservation of Energy

Test frames: Train in relative motion V_t with Lab at O. Ball falling with V_b when at height h in Lab

Mass: M_t = Train M = Earth m = ball



Test 1: Lab & Train Frame ; Test object: Ball

Lab Frame: Ball falling towards O with speed V_b

Dynamics: $E = mV_b^2/2 + mgh$

Kinematics: $E = mV_b^2/2 + mgh$ **Prediction matches kinematics reality check.**

Train Frame : Ball falling towards Train with speed $(V_b^2 + V_t^2)^{1/2}$

Dynamics: $E = m(V_b^2 + V_t^2)/2 + mgh$

Kinematics: $E = mV_b^2/2 + mgh$ **Prediction FAILS reality check.**

Test 2: Lab & Ball Frame ; Test object: Train

Lab Frame: Train in relative motion V_t

Dynamics: $E = M_t V_t^2/2$

Kinematics: $E = M_t V_t^2/2$ **..Prediction matches reality check.**

Ball Frame: Train moving towards ball at $(V_b^2 + V_t^2)^{1/2}$

Dynamics: $E = M_t(V_b^2 + V_t^2)/2 - M_t * gh$

Kinematics: ... $E = M_t V_t^2/2$ **Prediction FAILS reality check.**

⇒ **Both null hypotheses are False.**

Conclusion: There is only one inertial frame in this universe: the lab or ECEF reference frame.