Classical mechanics remains the oldest branch of physics. Indeed, it is so old that fundamental concepts of inertia and forces is ingrained in our culture. Despite this not everyone has a solid grasp on what seems to be fundamental or simple, these questions are meant to tax your understanding. Enjoy!

1 Classical Mechanics

1.1 Does it stop?

Consider ideal conditions[1] in which there is a hard ball rolling without slipping on a floor with friction. This floor is infinite in extent, and there is a gravitational force pulling the ball to the ground at constant magnitude, does the ball ever stop? or does it roll forever?

Credit: Physics Problems to Challenge Understanding

1.2 Another Question by Some Ambitious Fellow

Nothing yet!

1.3 Why does anything move at all?

Consider a student tossing up a ball, Newton's third law claims that for every action there is an equal and opposite reaction. That is, for bodies A and B, if A exerts a force on B then B exerts a force on A equal in magnitude, opposite and direction, and of the same physical nature[2].

If this is the case, how is it that a student can even toss up a ball? The ball is always pushing her arm down with equal force that she's pushing the ball with so how is it that things can move?

Credit: E. Mendez

2 Special Relativity

2.1 Does it sink or float?

Imagine a sea of superfluid[3] with density ρ, and a bullet with density ρ so that at rest the bullet can remain suspended in the ocean without floating or sinking. Next consider the same bullet shot through that very ocean with speed v along the horizontal.

From the ocean's point of view, the bullet will contract and therefore become more dense, and thus it will sink. While in the frame of the bullet, the ocean becomes more dense and thus the bullet should float. How do we resolve this

[1] No wind resistance, every shape is geometrically perfect to within precision limited by nature.

[2] Gravitational/gravitational, electrical/electrical, but never anything like gravitational/electrical.

[3] Note that this implies the existence of a gravitational field, which in our case is uniform.

paradox?

Credit: Elan Stopnitzky

2.2 Does the string break?

"…Three small spaceships, A, B, and C, drift freely in a region of space remote from other matter, without rotation and without relative motion, with B and C equidistant from A.

On reception of a signal from A the motors of B and C are ignited and they accelerate gently.

Let ships B and C be identical, and have identical acceleration programmes. Then (as reckoned by an observer in A) they will have at every moment the same velocity, and so remain displaced one from the other by a fixed distance. Suppose that a fragile thread is tied initially between projections from B and C. If it is just long enough to span the required distance initially, then as the rockets speed up, it will become too short, because of its need to [Lorentz-]Fitzgerald contract, and must finally break. It must break when , at a sufficiently high velocity, the artificial prevention of the natural contraction imposes intolerable stress.

Is it really so? …"

Credit: Bell, J.S.,'How to Teach Special Relativity' *Prog. Sci. Culter* **1** (1976)