The Lazy Donkey Paradox

Paradox

A paradox results when somebody seems to be applying logic correctly, but arrives at a conclusion that is clearly nonsense.

Paradoxes are often presented in physics as ways of disputing the laws of physics.
When presented with a paradox meant to dispute, you need to examine it closely in order to find out the logical flaw.

The Lazy Donkey Paradox:

A pioneer is carrying his family in a Conestoga Wagon on the Oregon trail.
Unfortunately, the donkey pulling the cart is extremely lazy.

The driver says "Go!"
and the donkey says "No!"

The driver says. "I said Go!"
but again the donkey responds "No, I won't!"

And the driver says, "We need to go. Why aren't you moving."
And the donkey says, "Because it is pointless."

The driver says, "What do you mean? Pull the cart, and we'll get to Oregon. How is that pointless."
And the donkey says, "Pulling a cart is pointless. It's pointless because of the laws of physics."

The driver of the cart is very puzzled by this, so the donkey elaborates.
"Newton's Third Law states that if A exerts a force on B, then B exerts a force on A with equal magnitude and opposite direction. Therefore, if I pull on the cart, the cart pulls back on me with the same magnitude, and we won't get anywhere."

Your goal is to help the driver sort out the apparent paradox.

1. Draw free-body diagrams of the donkey, the cart, the ground, and the earth, and the moment that the donkey begins to move.
Name each force, and identify the agent of that force.

There will be in total 14 forces, made of 7 action-reaction pairs.

4 forces act on the donkey.
4 forces act on the cart.
Many forces act on the ground, but only include 4 relevant reaction forces in your free-body diagram, and note that the net force on the ground is zero.
Many forces act on the earth, but only include 2 relevant reaction forces in your free-body diagram, and note that these forces are irrelevant to the motion of the earth.

Note #1:
Hoofed animals move by pressing their hoofs backwards into the ground.

Note #2:
Turning wheels experience static, not kinetic friction, if the wheel is not skidding.

Note #3:
An applied force that is applied via a rope is called *tension*.

2. Identify the seven pairs of action-reaction forces. Note that action-reaction pairs always act on *two different* free-body diagrams.

3. Identify two pairs of balanced forces. These are forces that have equal magnitude and opposite direction but are not action-reaction pairs because they act on the same free-body diagram.

4. Consider the magnitudes of the horizontal forces on the donkey and the cart.
Select magnitudes so that the donkey and cart both have a net force in the same direction, but Newton's Third Law is still respected.
Remember that we are considering the moment when the cart *begins to move*, so the net force acting on the cart and donkey should not be zero.

5. By referring to this free-body diagram analysis, write about 5 – 6 sentences refuting the donkey's paradoxical claim.