Physics 131- Fundamentals of Physics for Biologists I

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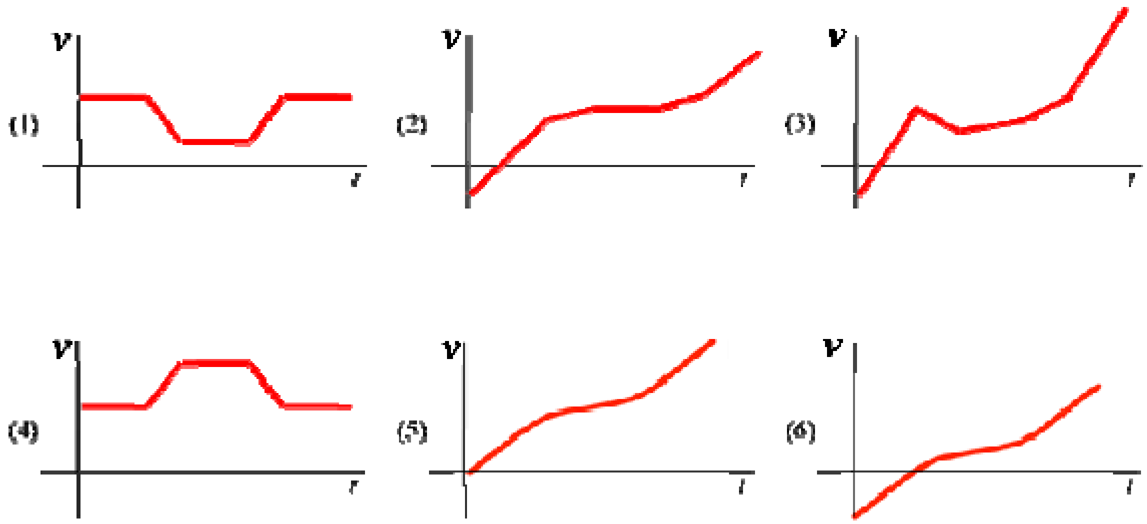
Outline

- Quiz 3
- Newton’s Laws
- What’s a force?
- The conceptual ideas behind Newton’s Laws

Quiz 2

1. (3 pts) A ball, starting from the position shown in the image on the right, is rolling at a constant speed along the horizontal part of the track. It comes to a hill and has enough speed to get over it.

Which of the graphs on the right could represent the **velocity** of the ball as a function of time?



Quiz 2

2. (3 pts) As discussed in recitation, many organisms grow isometrically, meaning that each linear dimension increases by the same factor. Let's assume that a cylindrical worm has a surface to volume ratio of 2 mm^{-1}. If it doubled all its dimensions when grown up, calculate the ratio of surface to volume for the grown-up worm.

Surface to ratio volume of grown worm?

Quiz 2

3. (2 pts) A vesicle (spherical bag of membrane) of diameter 2 µm is used to deliver a drug into cells of diameter 20 µm. The concentration of drug inside the vesicle is 10 mM (millimolar). What is the concentration of the drug inside the cell once the vesicle has released all its contents?

(1 mM = 10^{-3} M; 1 µM = 10^{-6} M)

A. 1 mM

B. 0.1 mM

C. 1 µM

D. 0.1 µM

E. 10 µM

F. Something else (what?)

Quiz 2

4. (2 pts) A vesicle of diameter 1 μm with S surface density of molecules fuses with a cell of 20 μm diameter. What is the surface density of molecules on the cell surface assuming the molecules distribute evenly over the cell.

A. S
B. S/20
C. S/40
D. S/400
E. S/8000
F. Something else (what?)

Kinematics and Dynamics

- Kinematics: Describing motion
  - Acceleration
- Dynamics: What causes motion
  - Forces and Newton's laws

Systems

- We will be considering situations in which many things acting on each other.
- In order to make sense of what's going on, we will focus on a few at a time and create models of what we think is happening.
- Sometimes we will focus on a set of things as our "system" and consider the influence of everything else as "external".
- Some times we will consider something's internal structure; other times we will consider it as a "black box".

System schemas

Can any force ever act upon an object without changing or altering its velocity?

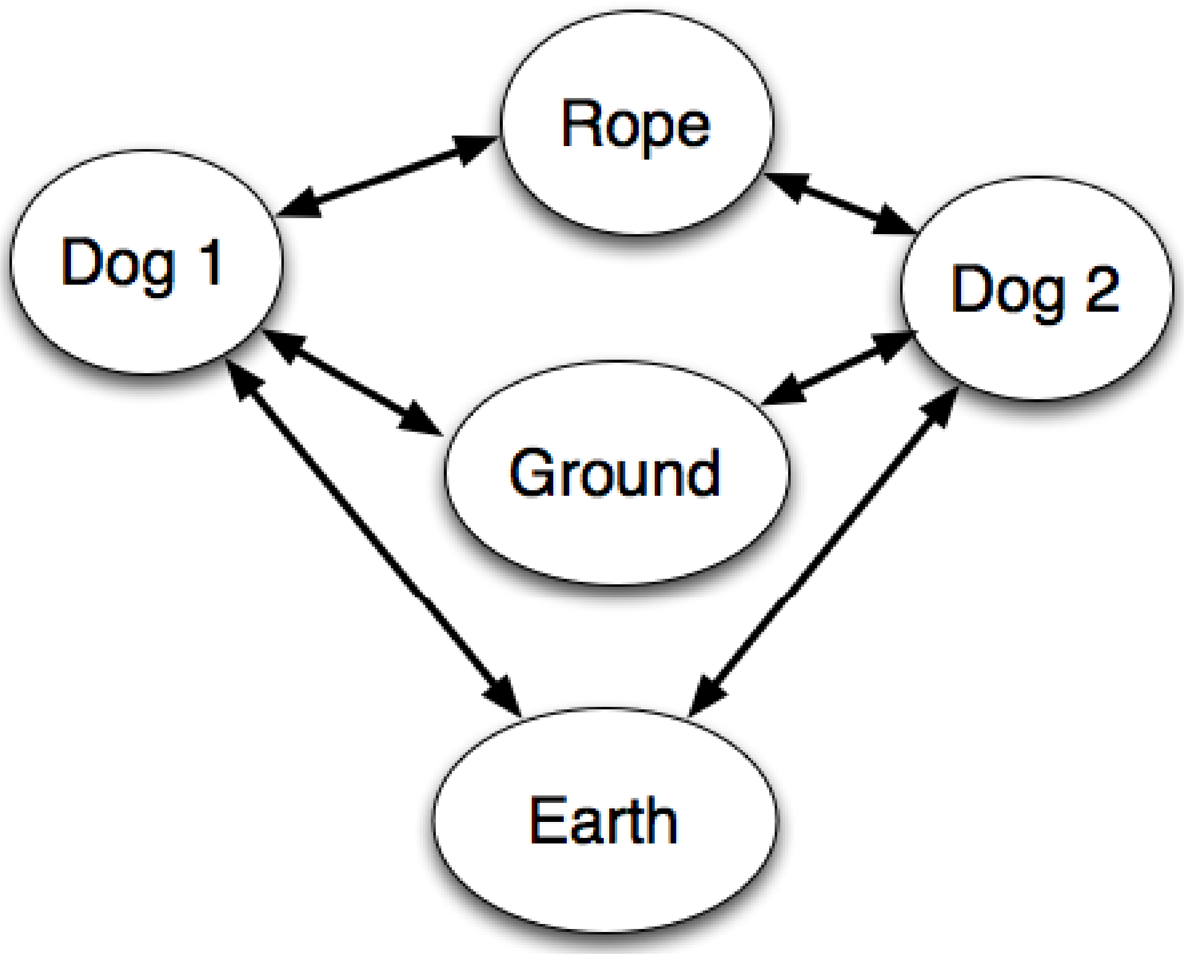
Are there forces without motion?

Draw a system schema **(Whiteboard, TA & LA)**

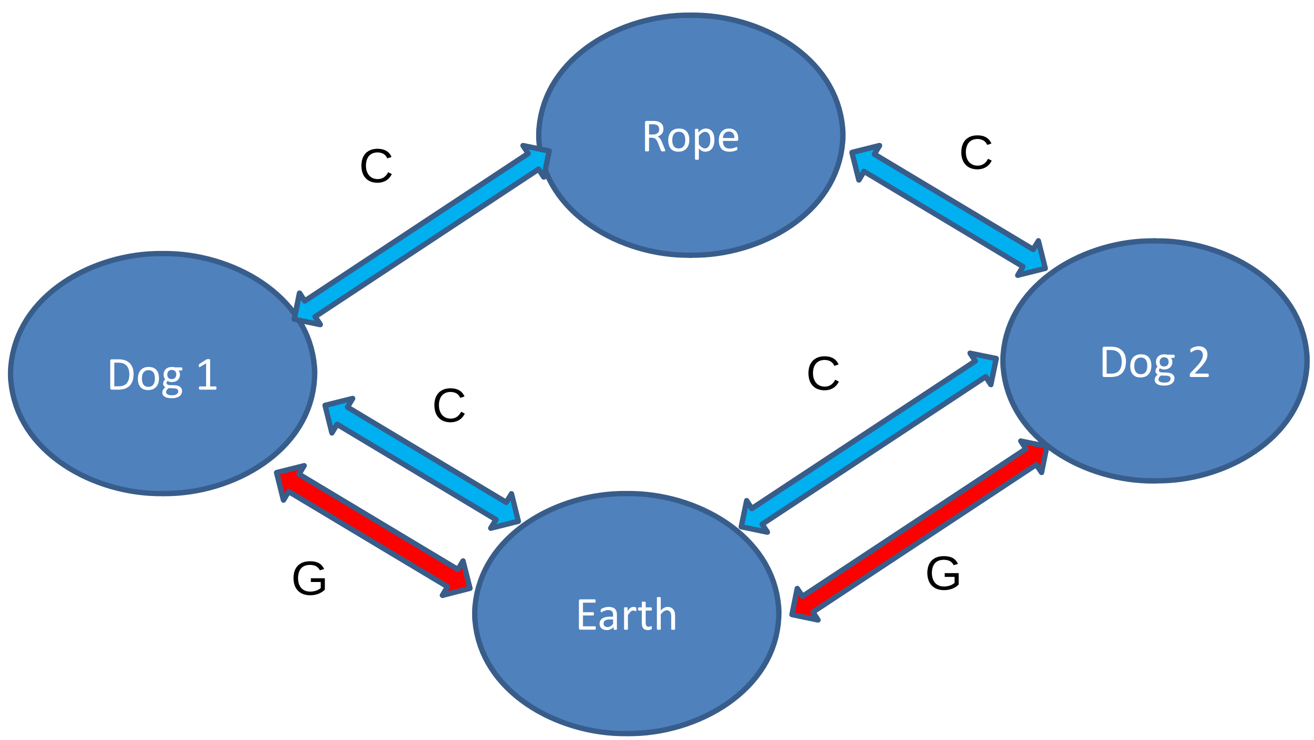
What “things” should be considered when thinking about what influences the motion – or non-motion – of the dogs?

How do they act on each other?

The System Schema for the two-dog tug-of-war

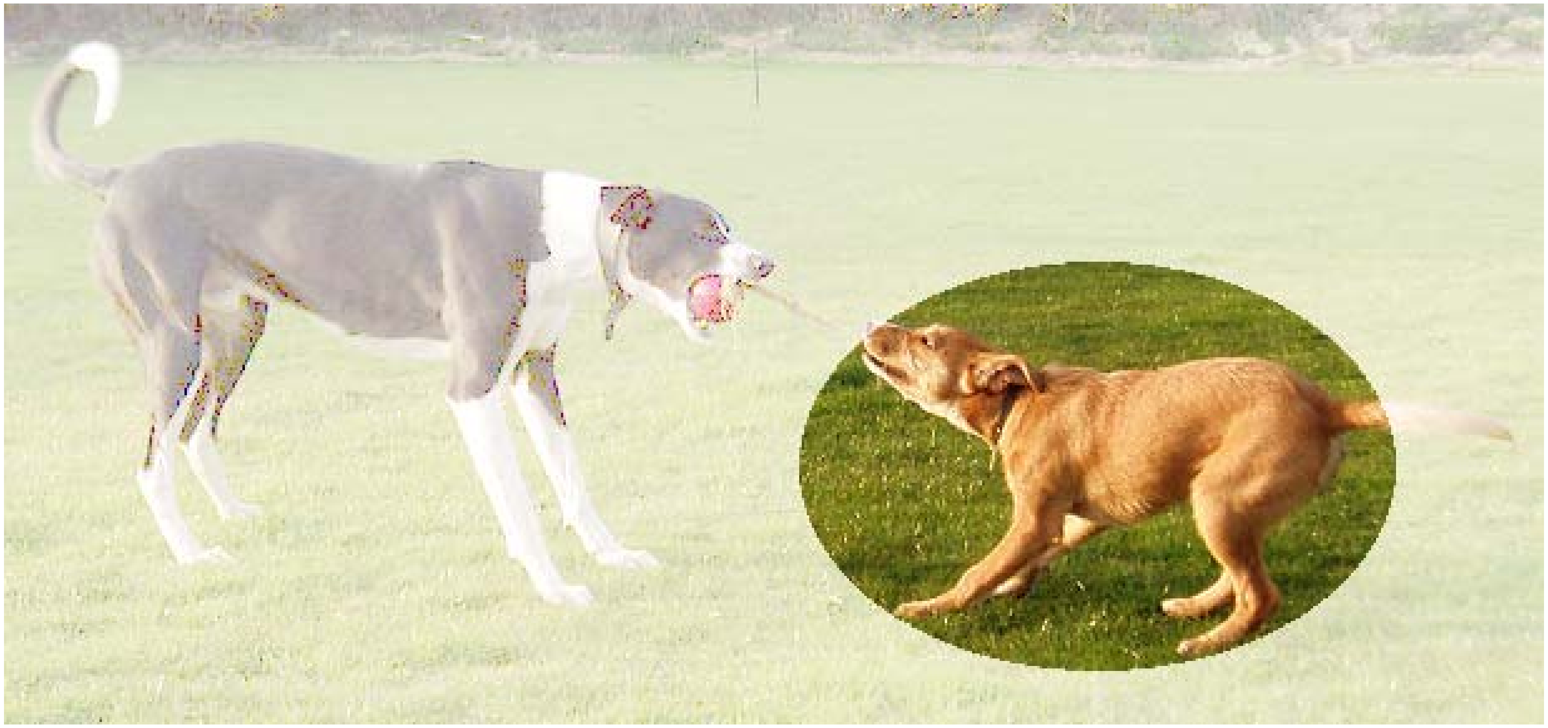


The System Schema
for the two-dog tug-of-war



What if we only want to consider the motion of dog 2?

Draw a SS on your whiteboard that identifies the influences acting on him.



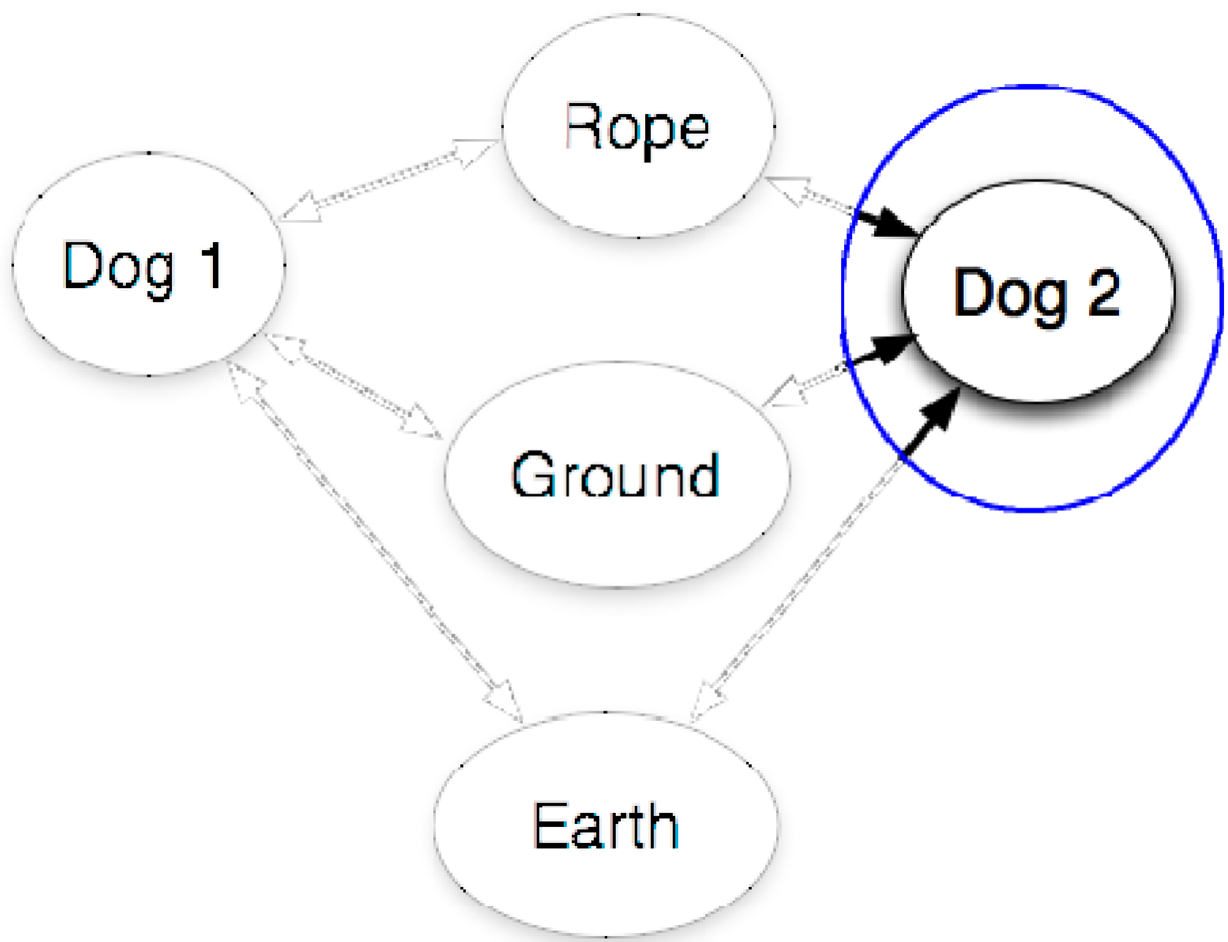
System Schemas

- A tool that allows you to be explicit about defining what you are going to choose to talk about and with how much complexity you are going to treat it.
- Specify
  - Relevant objects (and structures if needed)
  - Interactions between objects

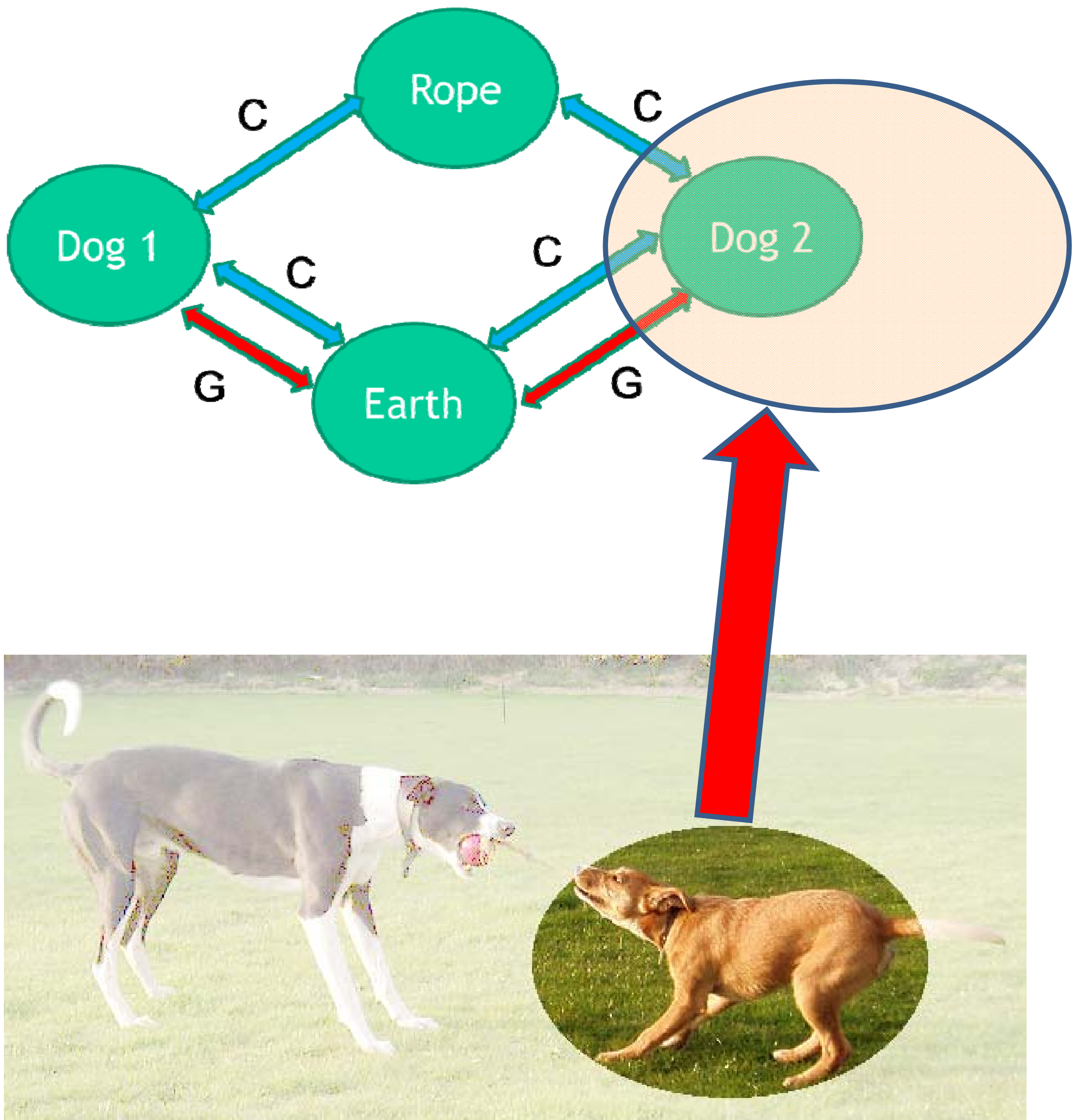
He isn't moving

- Yet there are clearly interactions that tend to make him move. What are they?
- Why doesn't he move?
- Is he also acting on the things that are acting on him?
- If so, why don't <u>they</u> move?

The System Schema
for the dog2 in the tug-of-war

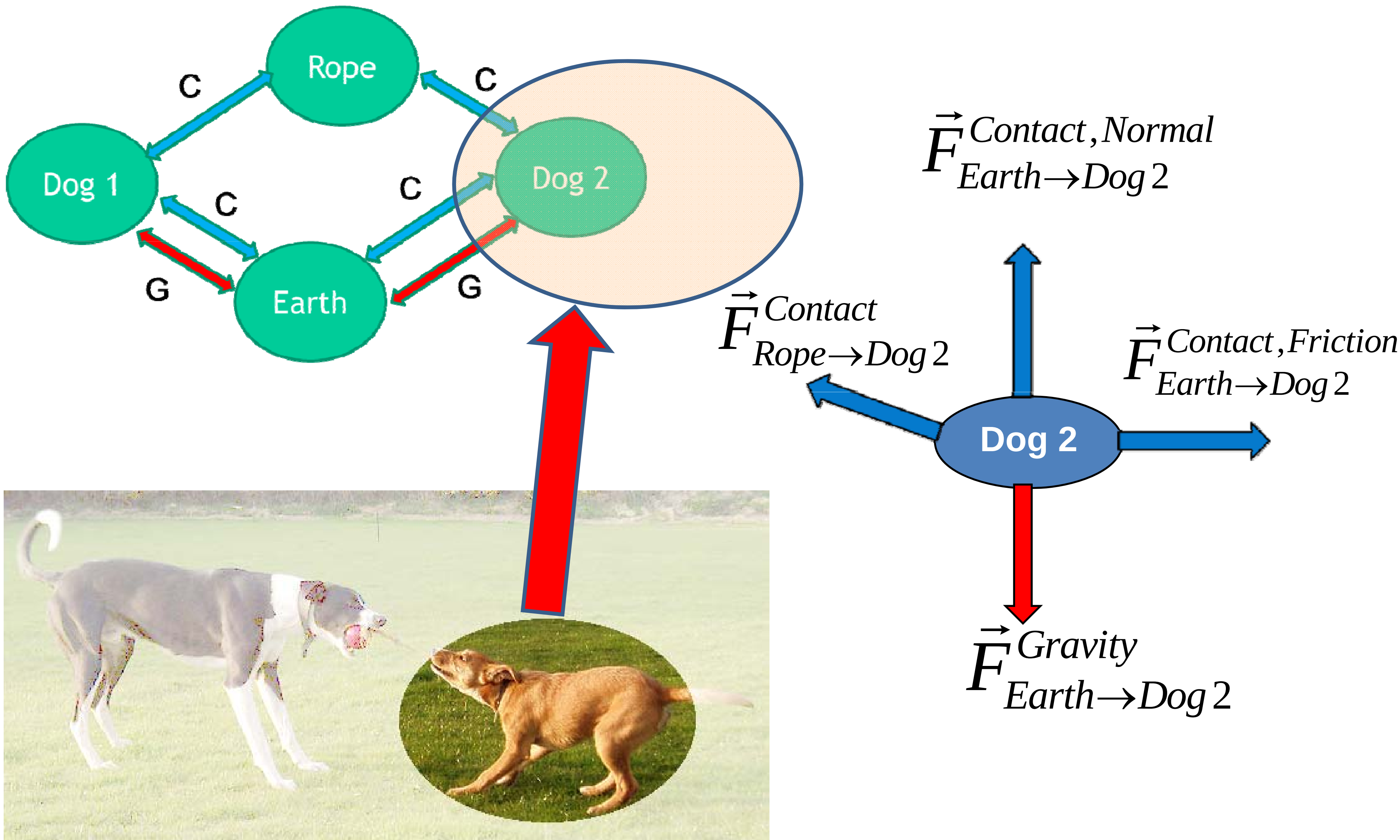


Draw free body diagram for dog 2
whiteboard (TA &LA)



How many interactions with dog 2?

Free body diagram for dog 2



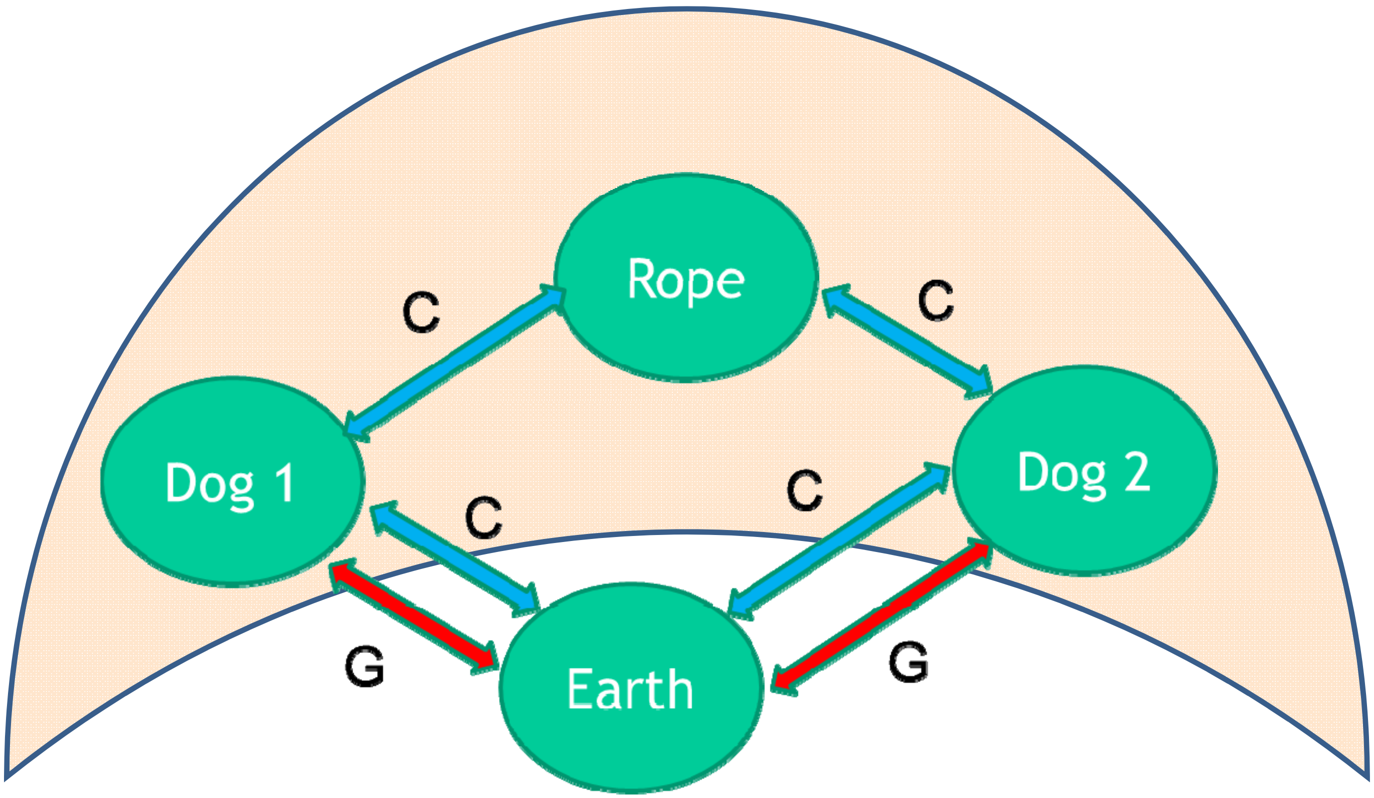
What if we want to consider the motion of both dogs?

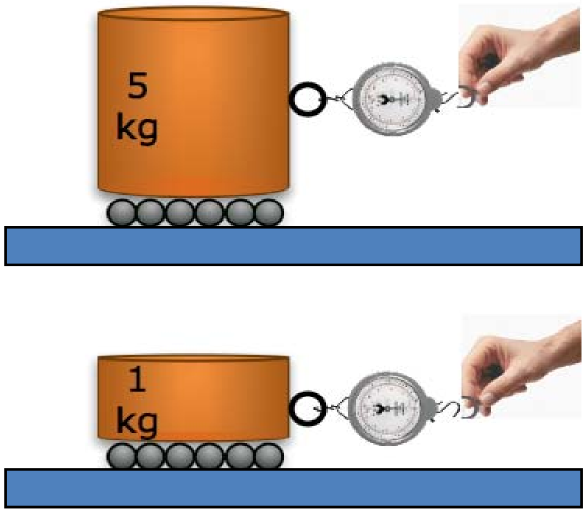
Free body diagram for the new "two dogs" object ***whiteboard (TA &LA)***

A plan for moving forward

- Specify “objects” – things we want to pay attention to and that we will “black box” by ignoring (for now) their structure.
- Identify “interactions” – other objects that have effects on the things we are paying attention to that tend to cause or inhibit their motions.
- Classify these interaction (“forces”) and study their properties.

The System Schema for the two-dog tug-of-war





You are pulling two weights along a table with equal force. Which one would speed up faster?

1. The 1 kg weight
2. The 5 kg weight
3. The would speed up the same way.
4. There is not enough information to tell.

The prof drops two metal spheres, one of 1 kg, the other of 5 kg. They hit the ground at (almost) exactly the same time. The force of gravity on the 5 kg weight is:

1. Greater than the force on the 1 kg weight
2. Less than the force on the 1 kg weight
3. Almost the same as the force on the 1 kg weight.
4. There is not enough information to tell.

What does this mean about the forces?

Systems

- We will be considering situations in which many things acting on each other.
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You are driving at a speed of 30 miles/hour when your car hits a long patch of black ice. Fortunately, the road is straight and there is nothing in front of you. You take your foot off the gas and jam on the brakes, keeping the steering wheel turned so the wheels point straight ahead. Your wheels stop spinning. What happens to your car?

A. It will quickly slow down and stop.
B. It will keep going at about the same speed.
C. It will skid sideways.
D. There is not enough information to tell.

But...?

- If no (horizontal) forces on you car means it keeps going at a constant speed,
  why do you have to push things
  to keep them going at a constant speed?
- Don't things naturally tend to stop and you have to push them to keep them going?
  That feels physically intuitive.
- Can you come up with examples that feel physically intuitive where things tend to keep going and you have to push them to make them stop?

Conceptual ideas underlying Newton's Laws: 1

- Objects respond only to influences acting upon them at the instant that those influences act. (**Object egotism**)
- All outside effects on an object being equal, the object maintains its velocity (including direction). The velocity could be zero, which would mean the object is at rest. (**Inertia**)
- Every change in velocity an object experiences is caused by the object interacting with some other object – forces. (**Interactions**)

Conceptual ideas underlying Newton's Laws: 2

- If there are a lot of different objects that are interacting with the object we are considering, the overall result is the same as if we add up all the forces as vectors and produce a single effective force -- the *net force*. (**Superposition**)
- When one object exerts a force on another, that force is shared over all parts of the structure of the object. (**Mass**)
- Whenever two objects interact, they exert forces on each other. (**Reciprocity**)

Foothold principles: Newton's Laws

- Newton 0:
  - An object responds **only** to the forces it feels and only at the instant it feels them.
- Newton 1:
  - An object that feels a net force of 0 keeps moving with the same velocity (which may = 0).
- Newton 2:
  - An object that is acted upon by other objects changes its velocity according to the rule

$$\vec{a}_A = \vec{F}_A^{net} / m_A$$

- Newton 3:
  - When two objects interact the forces they exert on each other are equal and opposite.

$$\vec{F}_{A\to B}^{type} = -\vec{F}_{B\to A}^{type}$$