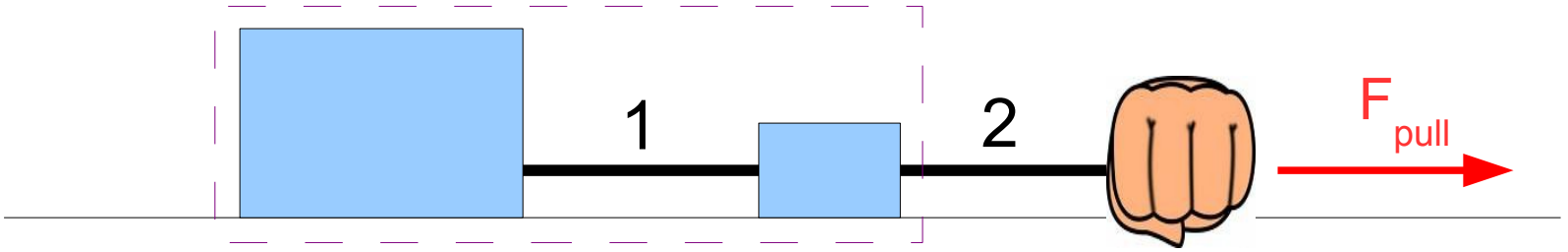
NEWTON'S THIRD LAW

"External" vs. "Internal" Force

- External Force:
  - Exerted on the system by something outside the system
- Internal Force:
  - Exerted by one part of the system on another part
- Newton's Second Law: $F_{net} = m\,a$
  - Where F_{net} is the net external force on the system
  - So only external forces can produce acceleration
  - You can't pick yourself up by your bootstraps!

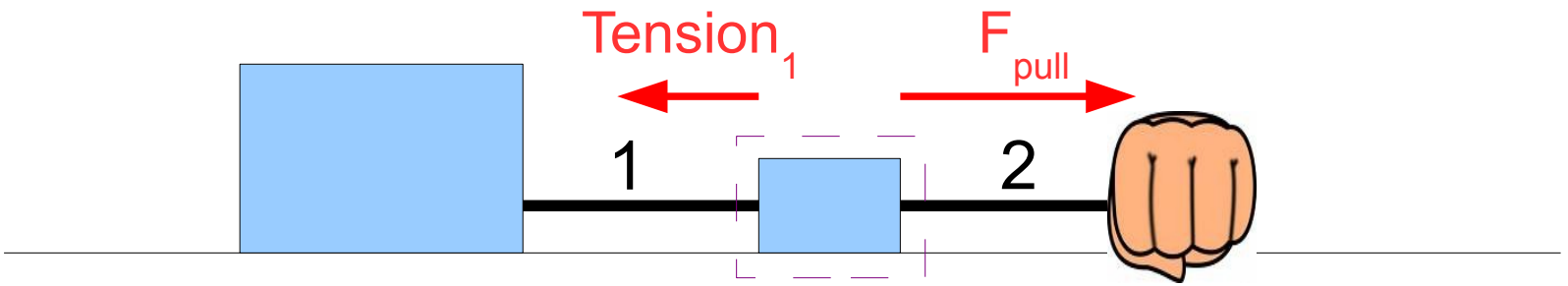
“External” vs. “Internal” Force: An Example



- Let our “system” contain both blocks and rope 1
  - We are free to choose any objects we want to make our system (the boundaries are created by our imagination)

- Hand pulls on rope 2, causing system to accelerate
  - Hand does NOT pull on rope 1 directly!
  - Tension in rope 1 is an internal force
  - The external force F_{pull} accelerates the system

“External” vs. “Internal” Force: Another View

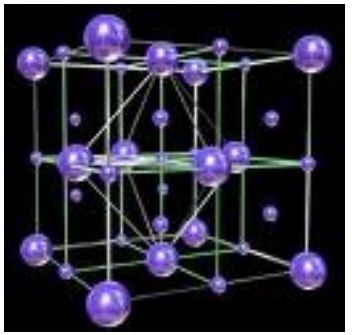


- Now let our “system” contain only the small block
  - Now the tension in rope 1 is an external force
  - F_{pull} and $Tension_1$ can be combined into a net force
  - Newton's 2nd Law: Find the small block's acceleration

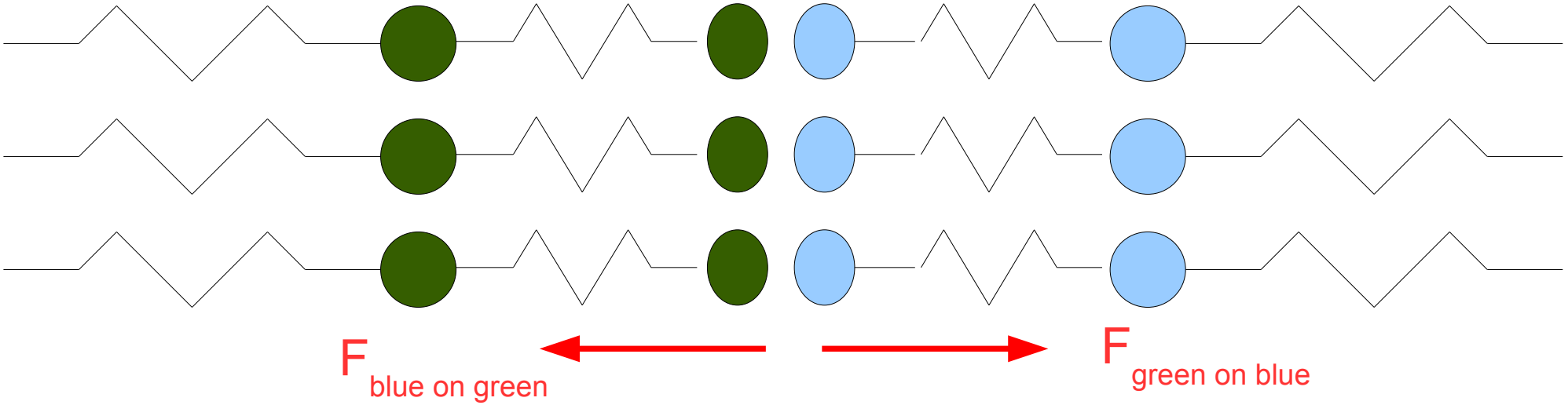
- No matter what we choose to use as our system, Newton's Laws provide a single, consistent answer for acceleration!

Forces at the Atomic Level

- Atoms in matter push (or pull) on each other as if they were connected by springs:



- When objects are in contact, the “springs” between the atoms in both objects compress (or stretch)

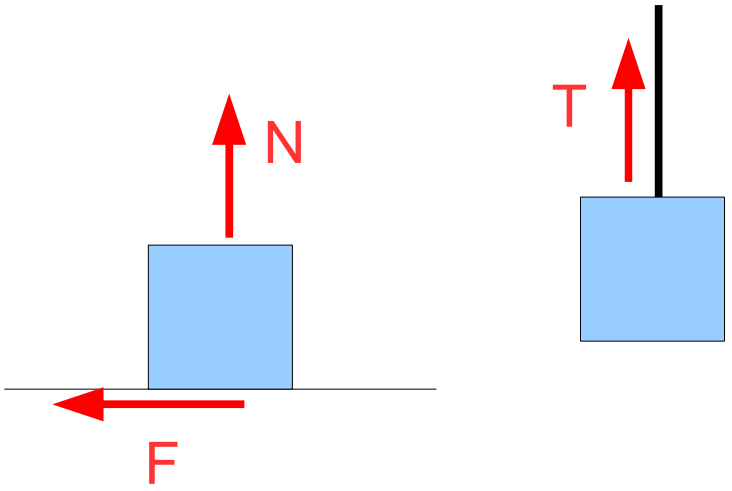


“Action” and “Reaction” Forces

- It is impossible for atoms to exert a force without having a force exerted back on them
  - “Action Force” – Object A pushes on Object B
  - “Reaction Force” – Object B pushes back on Object A
- Forces always come in pairs!
  - One force is external – exerted on the system
  - One force is internal – exerted by the system
- Deciding which force is the “action” and which is the “reaction” is arbitrary

Forces in our Everyday Experience

- Atomic Forces
  - Normal Force
  - Tension
  - Friction

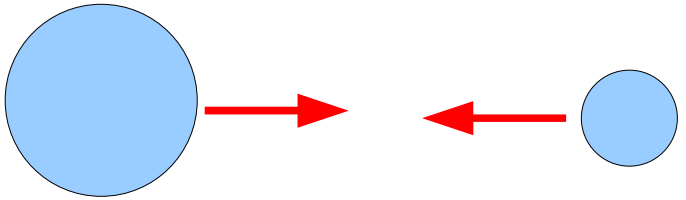


- Gravity
  - Weight of objects
  - Orbits of planets and moons

- Gravity also obeys the “action/reaction pair” rule
  - So every force has a reaction force!

Newton's Third Law

- “Every action has an equal and opposite reaction.”
  - The strengths of the action/reaction pair are equal
  - The directions of the action/reaction pair are opposite



- If A exerts a force on B, then B exerts an equal and opposite force back on A
  - This law allows us to understand interactions and collisions between objects

Newton's Third Law Example

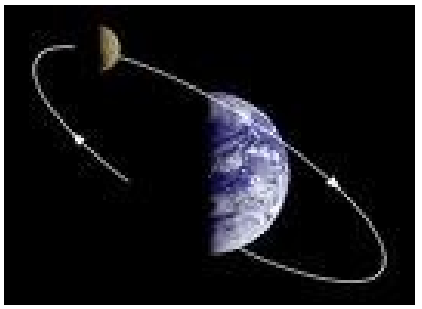
- Throw a rock off of a cliff

- While the rock falls, gravity pulls down on it
  - What is the reaction force to this action?

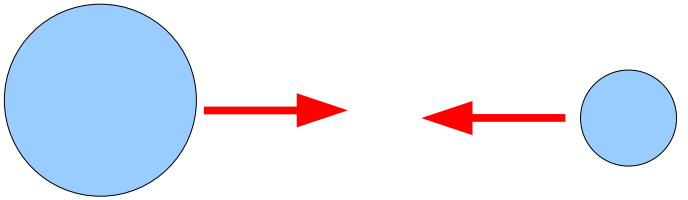
- Answer: Rock pulls up on Earth!
  - Action:Earth on rock (down) Reaction: Rock on Earth(up)
  - Earth moves only a tiny bit because of its huge mass
  - Still, rock has its own gravity (very weak!)

Newton's Third Law and Orbits

- Consider a smaller object orbiting a larger one:
  - Moon orbiting around planet
  - Planet orbiting around star



- Newton's Third Law:

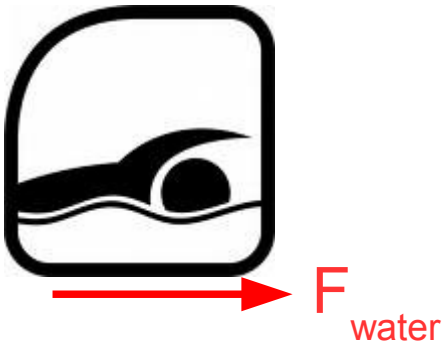


  - The larger object will not stand still!
  - Instead, it will “wobble” as the smaller object pulls on it
  - Astronomers have discovered “extrasolar planets” by looking for wobbling stars

Newton's Third Law – Moving Yourself

- For a system is to propel itself forward:
  - The system must have a forward external force on it
  - Newton's Third Law: A forward external force can be created by pushing backward on something else

- Examples:
  - Walking
  - Swimming
  - Tire-based propulsion
  - Jets and rockets

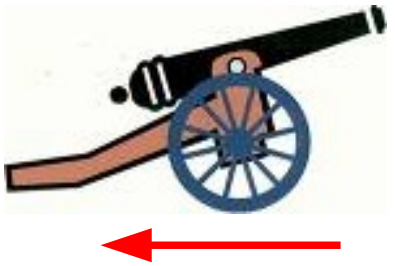


Propelling Something Else – Recoil

- To propel any object, a forward force must be exerted on it
  - This means it exerts a backward force
  - Sometimes the object doing the forward pushing will be held in place by another force, otherwise it will recoil

- Examples:
  - Throwing

F_{ground} (prevents recoil)



Recoil

  - Firing a projectile

Summary

- Every action has an equal and opposite reaction
- One force is exerted on the object, the other force is exerted by the object
- The masses of the objects determine how they move due to the action/reaction pair of forces