Newton's Laws

Newton's Contributions

- Calculus
- Light is composed of rainbow colors
- Reflecting Telescope
- Laws of Motion
- Theory of Gravitation

Newton's First Law
(law of inertia)

1

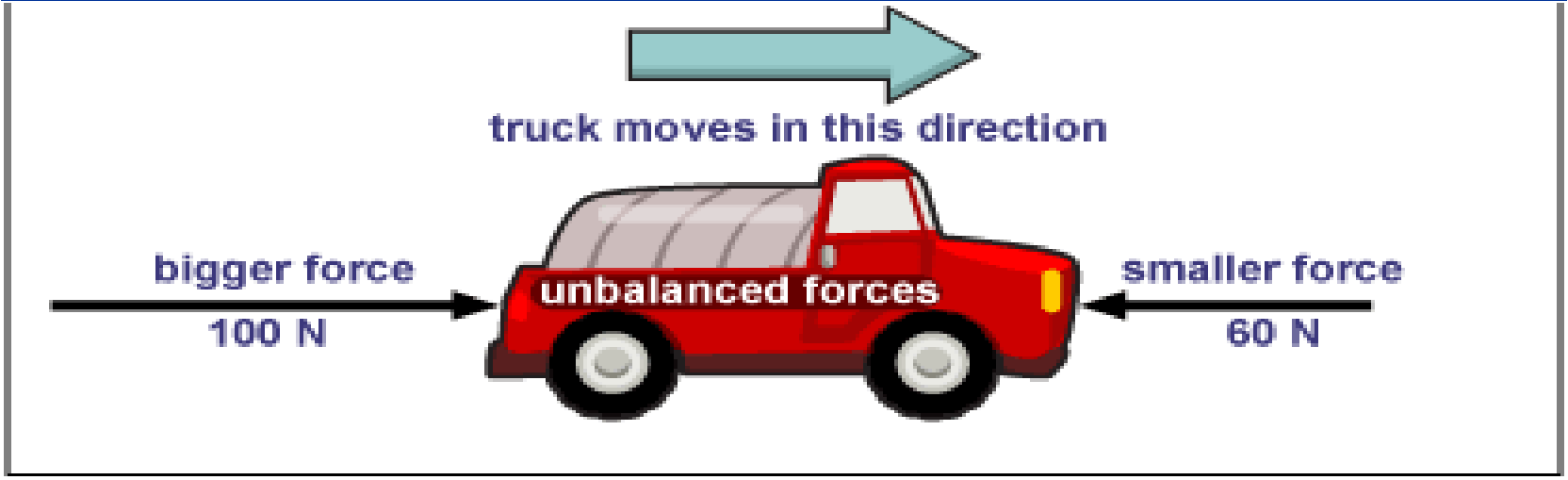
An object at rest tends to stay at rest and an object in motion tends to stay in motion unless acted upon by an unbalanced force.

Balanced Force

Equal forces in opposite directions produce no motion

Unbalanced Forces

Unequal opposing forces produce an unbalanced force causing motion



If objects in motion tend to stay in motion, why don't moving objects keep moving forever?

Things don't keep moving forever because there's almost always an unbalanced force acting upon them.

A book sliding across a table slows down and stops because of the force of *friction*.

If you throw a ball upwards it will eventually slow down and fall because of the force of *gravity*.

Newton's First Law (law of inertia)

- MASS is the measure of the amount of matter in an object.

- It is measured in Kilograms

Newton's First Law (law of inertia)

- INERTIA is a property of an object that describes how much it will resist change to the motion of the object

- more mass means more inertia

1st Law

- Unless acted upon by an unbalanced force, this golf ball would sit on the tee forever.

What is this unbalanced force that acts on an object in motion?

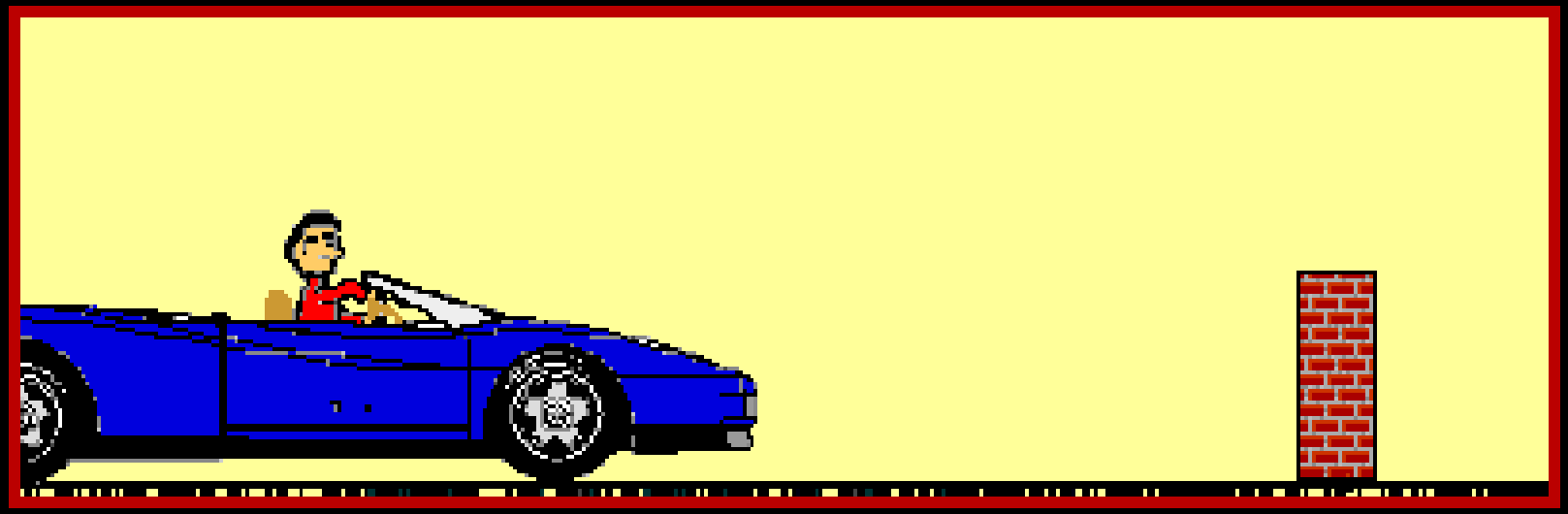
Friction!

- There are four main types of friction:
  - Sliding friction: ice skating
  - Rolling friction: bowling
  - Fluid friction (air or liquid): air or water resistance
  - Static friction: initial friction when moving an object

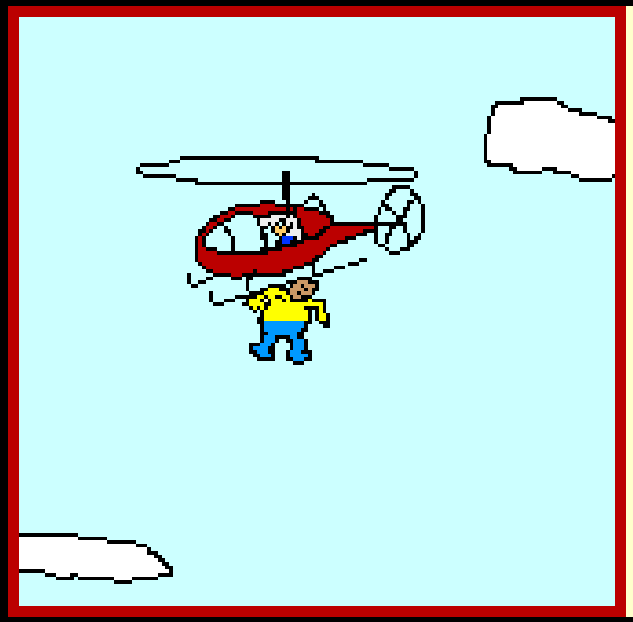
1st Law

- Once airborne, unless acted on by an unbalanced force (gravity and air – fluid friction) it would never stop!

Inertia



Terminal Velocity



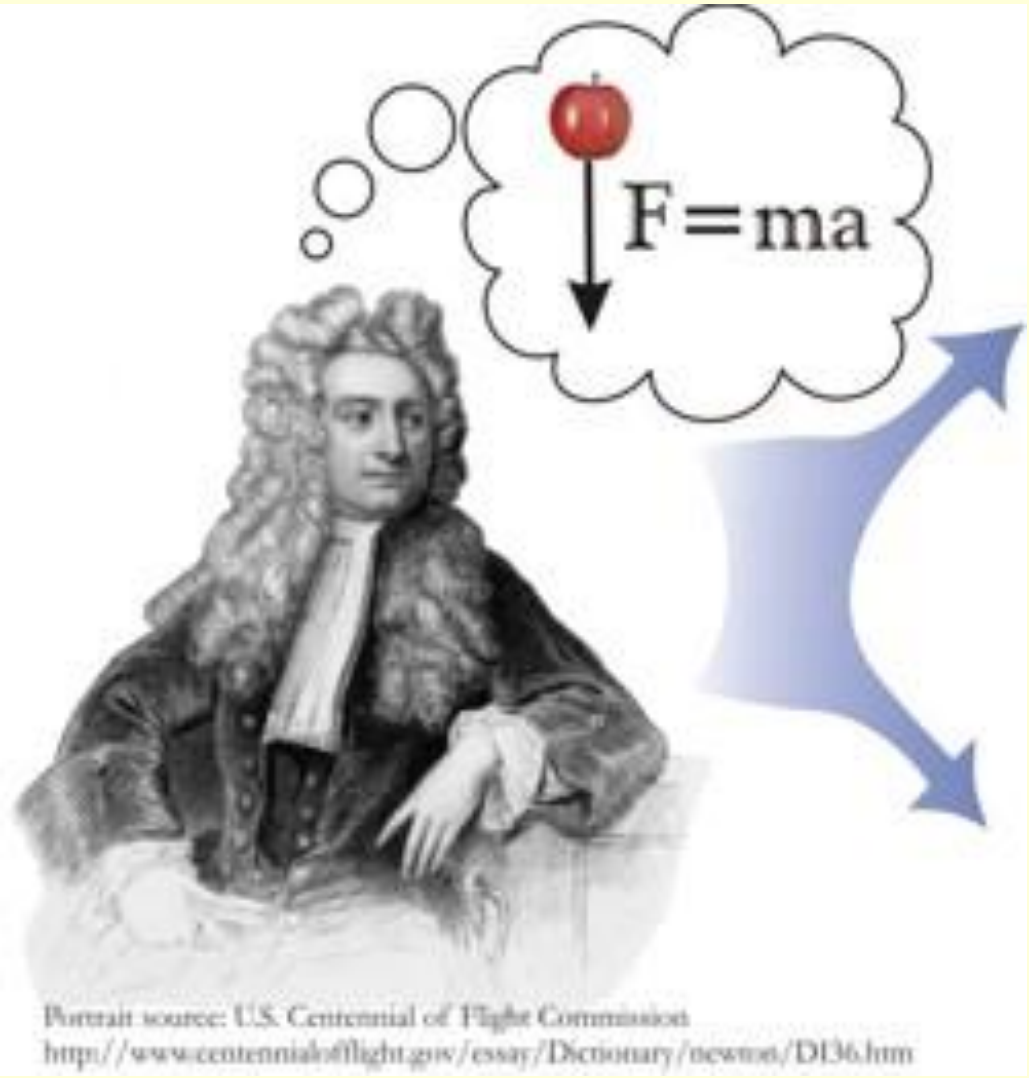
$$a = \frac{F_{net}}{m}$$

$$a = \frac{1000\ N}{100\ kg}$$

$$a = 10.0\ m/s^2$$

(down)

Newton's Second Law



Force equals mass times acceleration.

F = ma

Newton's Second Law

- Force = Mass x Acceleration
- Force is measured in Newtons

ACCELERATION of GRAVITY(Earth) = 9.8 m/s^2

- **Weight (force) = mass x gravity (Earth)**

Moon's gravity is 1/6 of the Earth's

If you weigh 420 Newtons on earth, what will you weigh on the Moon?

70 Newtons

If your mass is 41.5Kg on Earth what is your mass on the Moon?

Newton's Second Law

- WEIGHT is a measure of the force of gravity on the mass of an object

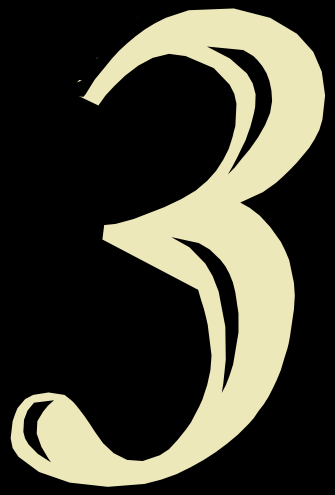
- measured in Newtons

Newton's Second Law

One rock weighs 5 Newtons. The other rock weighs 0.5 Newtons. How much more force will be required to accelerate the first rock at the same rate as the second rock?

Ten times as much

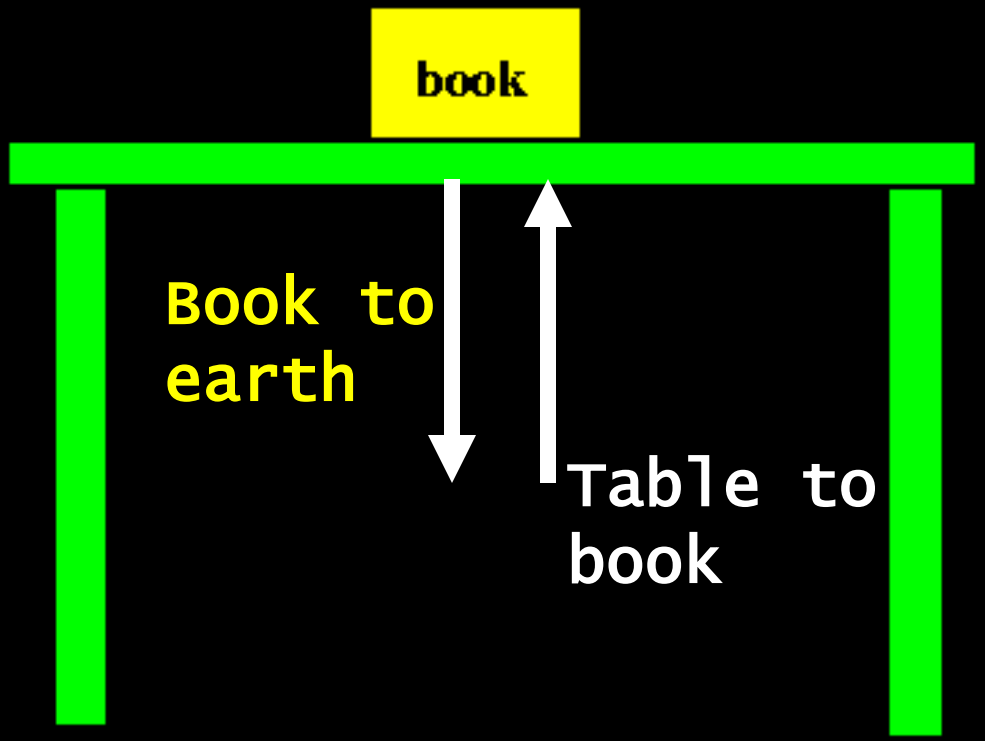
Newton's Third Law



For every action there is an equal and opposite reaction.

Newton's 3rd Law

- For every action there is an equal and opposite reaction.



Think about it . . .

What happens if you are standing on a skateboard or a slippery floor and push against a wall? You slide in the opposite direction (away from the wall), because you pushed on the wall but the wall pushed back on you with equal and opposite force.

Why does it hurt so much when you stub your toe? When your toe exerts a force on a rock, the rock exerts an equal force back on your toe. The harder you hit your toe against it, the more force the rock exerts back on your toe (and the more your toe hurts).

Newton's Third Law

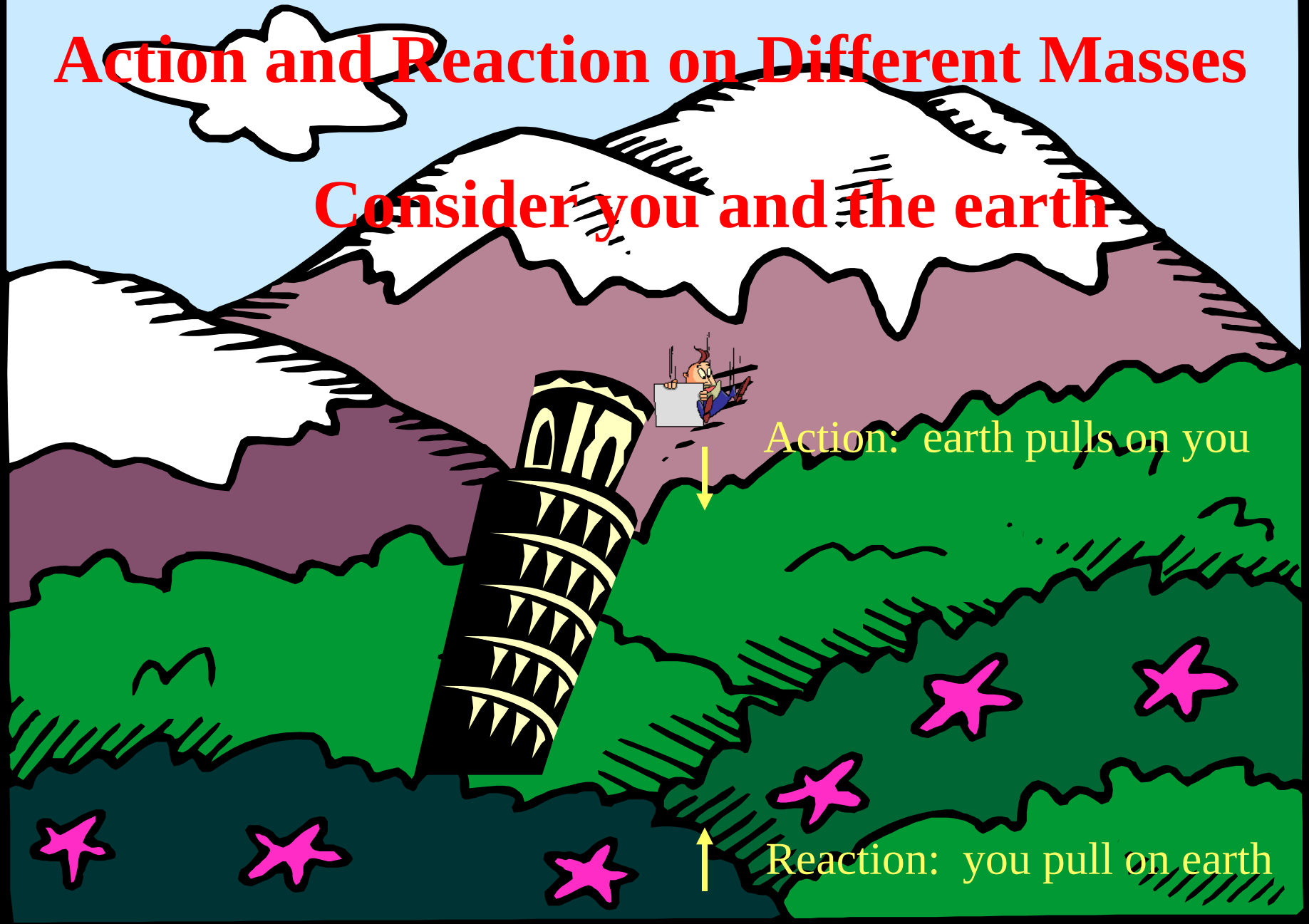
- A bug with a mass of 5 grams flies into the windshield of a moving 1000kg bus.
- Which will have the most force?
- The bug on the bus
- The bus on the bug

Newton's Third Law

- The force would be the same.
- Force (bug)= $m \times A$
- Force (bus)= $M \times a$

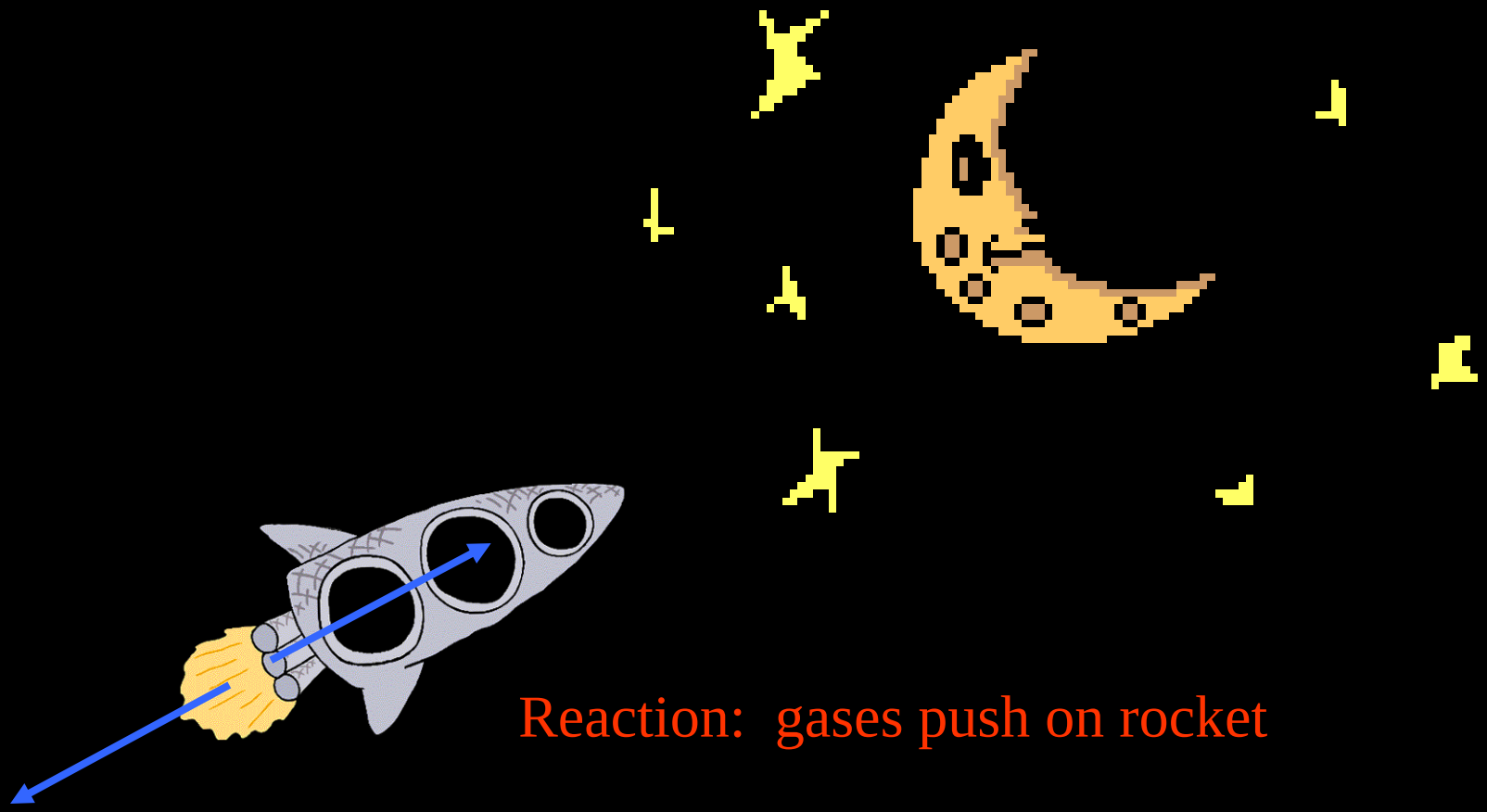
Action and Reaction on Different Masses

Consider you and the earth



Reaction: road pushes on tire

Action: tire pushes on road


Reaction: gases push on rocket
Action: rocket pushes on gases

Consider hitting a baseball with a bat. If we call the force applied to the ball by the bat the *action force*, identify the *reaction force*.

(a) the force applied to the bat by the hands

(b) the force applied to the bat by the ball

(c) the force the ball carries with it in flight

(d) the centrifugal force in the swing

Newton's 3rd Law

- Suppose you are taking a space walk near the space shuttle, and your safety line breaks. How would you get back to the shuttle?

Newton’s 3rd Law

- The thing to do would be to take one of the tools from your tool belt and throw it is hard as you can directly away from the shuttle. Then, with the help of Newton's second and third laws, you will accelerate back towards the shuttle. As you throw the tool, you push against it, causing it to accelerate. At the same time, by Newton's third law, the tool is pushing back against you in the opposite direction, which causes you to accelerate back towards the shuttle, as desired.

Review

Newton's First Law:

Objects in motion tend to stay in motion and objects at rest tend to stay at rest unless acted upon by an unbalanced force.

Newton's Second Law:

Force equals mass times acceleration ($F = ma$).

Newton's Third Law:

For every action there is an equal and opposite reaction.

Newton's Laws

1st law: Homer is large and has much mass, therefore he has much inertia. Friction and gravity oppose his motion.

2nd law: Homer's mass x 9.8 m/s/s equals his weight, which is a force.

3rd law: Homer pushes against the ground and it pushes back.