NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

+ Text Only Site
+ Non-Flash Version
+ Contact Glenn

FIND IT @ NASA + GO

+ ABOUT NASA | + NEWS & EVENTS | + MULTIMEDIA | + MISSIONS | + MY NASA | + WORK FOR NASA

About Rockets

Start Your Journey
Rocket Research 101
Rocket Research 102
Rocket Research 103

Educator Section
Rocket Safety
The Simulators
Install 3D Simulator
Home

START YOUR JOURNEY - LAWS OF MOTION

Newton's Laws of Motion Challenge

You chose :

1. The Law of Inertia:

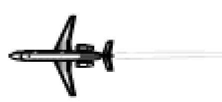
"An object at rest tends to stay at rest and an object in motion tends to stay in motion."

This choice is not the right one for the example.

However, it still applies to rocket flight! It's easiest to see how Newton's First Law works when the rocket gets above the Earth's atmosphere (to avoid air resistance).

Because there is very little friction in orbit, when a satellite is "in motion" it will stay "in motion," orbiting the Earth continually just as Newton predicted...until something (a force, such as a rocket motor) comes along to change that condition.

There are some residual air molecules up where the satellites orbit, so they do encounter very slight air resistance, which can eventually slow them down (it takes many years). We call this "**orbital decay.**" Rocket boosters on a satellite can correct the decay from time to time. Otherwise, the satellite must be repositioned.



Newton's First Law is also valid on Earth. However, on the surface of the planet, air resistance is present and slows a moving object. To counter air resistance, a continuous forward force must be applied.

For example, automobiles must constantly run their engines in order to maintain a forward movement. An automobile has additional friction from the wheels, wheel bearings, and the road. The sole purpose of running the automobile engine continuously is to overcome all the different friction sources. Otherwise, a small push would keep an automobile moving forever. (Hills and valleys present special situations...but that's another story.)

>> Try Again - Back to the Thrust page

Any comments, concerns, or questions should be addressed to:
Developer: **David Mazza**
Responsible NASA Official: **Jo Ann Charleston**

START YOUR JOURNEY - LAWS OF MOTION

Newton's Laws of Motion Challenge

You chose :

2. The Law of Proportionality:

"The acceleration of an object is directly proportional to the net force and inversely proportional to its mass." This can be expressed in equation form: **Force = (Mass) x (Acceleration)**

This choice is not the right one for the example.

However, it still applies to rocket flight! When a **net** (or excess) **force** is applied to an object, it will accelerate in the direction of that force. In physics we say that the acceleration is directly proportional to the force.

Of course, the more massive the object, the slower it will accelerate. For this case we say that the acceleration is inversely proportional to the mass (as mass increases, the acceleration decreases, and vice-versa).

We write the equation as:

Force (thrust) = Mass x Acceleration

Or we can write it as:

Acceleration = Force ÷ Mass

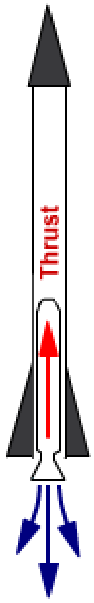
Example: The force is 25.0 lbs of thrust. The rocket has a mass of 1.400 kilograms. Calculate its acceleration during HORIZONTAL movement on some frictionless surface. (Let's not fight gravity yet.)

Solution: First, let's change pounds of thrust into the metric equivalent of pounds...a unit called Newtons. Multiply 4.45 Newtons per pound times the number of pounds of force. So...25.0 lbs x 4.45 Newtons/lb = 111.3 Newtons of metric force.

Acceleration = (111.3 Newtons) ÷ (1.4 kilograms)
Acceleration = 79.5 Newtons per kilogram
= 79.5 meters per second each second

That means that the rocket's speed increases by 79.5 meters per second every second.

If you fire the rocket vertically, its acceleration will be a bit less since



it will struggle against gravity. That calculation is:

Acceleration = Force ÷ Mass

If a rocket moves vertically, there are TWO forces: (1) the upward thrust of 25 pounds, or 111.3 Newtons, and (2) the downward pull of gravity, which is the rocket's weight.

First, what does the rocket weigh?
The rocket has a mass of 1.40 kilograms. Any object's weight is found by multiplying its mass times the force of gravity. On the surface of the Earth, the force of gravity is 9.80 Newtons for every kilogram of mass (written as 9.8 N/kg).

So,

Weight = mass x gravitational force
Weight = (1.40 kilograms) x (9.80 Newtons per kilogram)
Weight = 13.7 Newtons

Try a conversion on your own.

Let's use the weight in the acceleration equation:

Acceleration = Force ÷ Mass
Acceleration = (111.3 Newtons – 13.7 Newtons) ÷ (1.4 kilograms)

Notice we SUBTRACT the weight. It's holding our rocket back!

Acceleration = 69.7 meters per second per second.

>> Try Again - Back to the thrust page

Conversion from Metric System

A conversion challenge!
1. What is the value of acceleration in miles per hour per second?
2. What does it mean?

Needed Data:
a) in one mile there are 1,609 meters
b) there are 3,600 seconds in 1 hour

Enter your answer here: ______

>> Hint
>> Check answer

About Rockets
Start Your Journey
Rocket Research 101
Rocket Research 102
Rocket Research 103
Educator Section
Rocket Safety
The Simulators
Install 3D Simulator
Home

START YOUR JOURNEY - LAWS OF MOTION

Newton's Laws of Motion Challenge

You Chose :

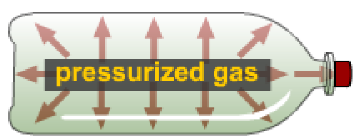
3. The Law of Action-Reaction:

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

You chose wisely!!

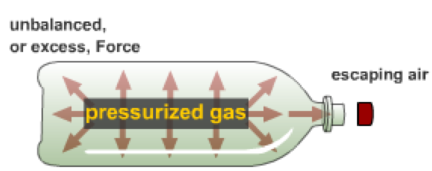
Newton's Third Law of Action-Reaction is the essence of jet and rocket propulsion. Let's look at a diagram of the combustion chamber of a rocket (essentially your bottle).

If it were closed, the pressurized air would push out on all sides equally, like a balloon.



Closed Bottle

However, open the nozzle and the escaping air leaves an unbalanced force on the opposite side of the bottle.



Open Bottle

The **"action"** is the movement of air out of the nozzle. The **"reaction"** is the forward motion of the bottle.

Part of what determines the bottle's velocity is the **MOMENTUM** (momentum = mass x velocity) of the escaping particles. There is another law, called the **Conservation of Momentum Law**, that requires the momentum of the bottle (bottle mass x bottle velocity) to be equal but opposite to the momentum of the escaping air (air mass x air velocity).

Can you now think of why expelling water might be better than expelling just air?
a) Water is heavier than air.
b) Water is lighter than air.
c) All my friends will get soaked.
d) None of the above.