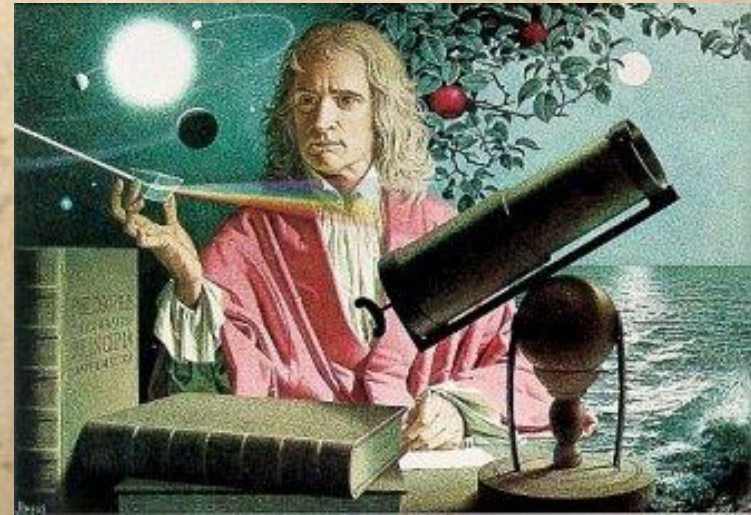


FORCES & MOTION



WHO WAS ISAAC NEWTON?



- BORN: DECEMBER 25, 1643 IN ENGLAND
(THE SAME YEAR GALILEO DIED)
- KNIGHTED BY QUEEN ANNE IN 1705 TO
BECOME SIR ISAAC NEWTON AT AGE 64
- THE FIRST PERSON TO DESCRIBE UNIVERSAL
GRAVITATION AND TO SPLIT WHITE LIGHT INTO
COLORS USING A PRISM

REVIEW OF GRAVITY

- GRAVITY: THE FORCE OF ATTRACTION BETWEEN OBJECTS DUE TO THEIR MASS
- THE LAW OF UNIVERSAL GRAVITATION STATES THAT:
 - ALL OBJECTS IN THE UNIVERSE ATTRACT EACH OTHER THROUGH GRAVITATIONAL FORCES.
 - THE SIZE OF THE FORCE DEPENDS ON THE MASSES OF THE OBJECTS THE DISTANCE BETWEEN THESE

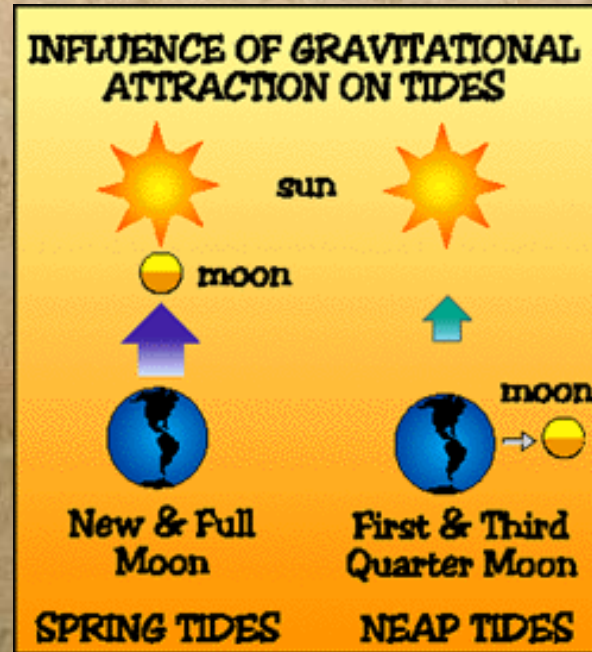


RULES OF GRAVITY



Gravitational force is
SMALL

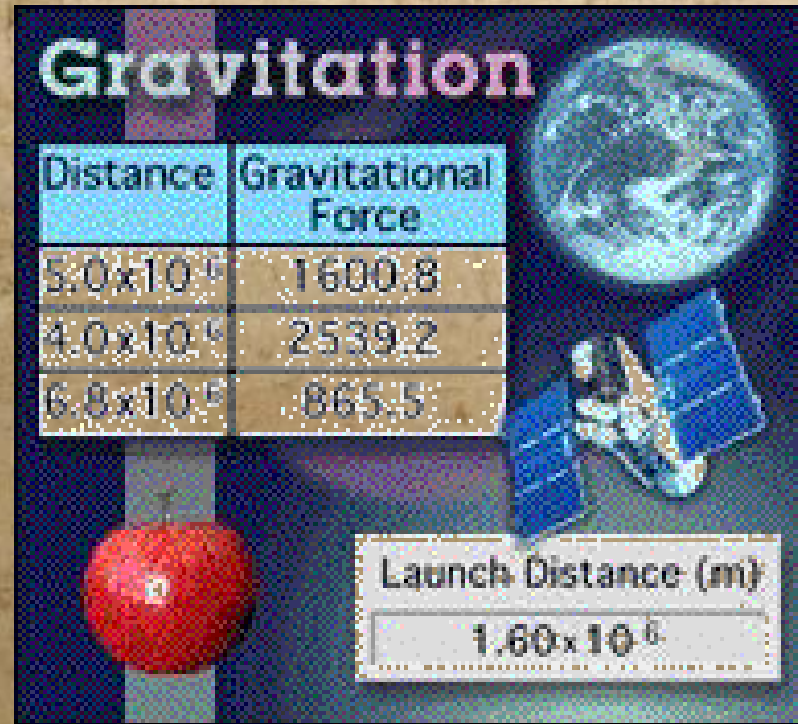
Between objects that
have a SMALL MASS



Gravitational
force is
LARGE
between
objects that
have a
LARGE
MASS

**Rule #1: The Gravitational Force increases
as the mass of the object increases.**

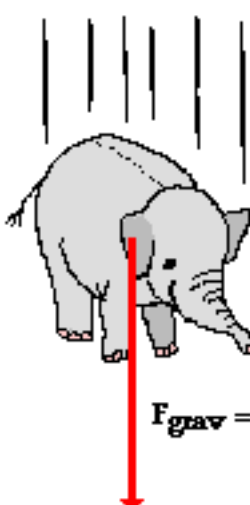
RULES OF GRAVITY



Rule #2: The Gravitational force decreases as distance between the objects increase.

GRAVITY & ACCELERATION

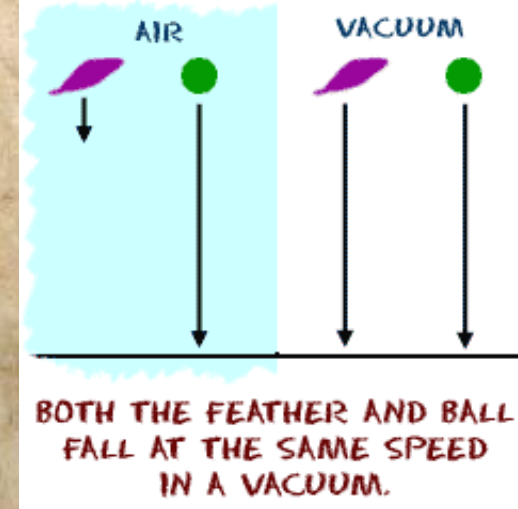
- DIFFERENT OBJECTS FALL TO THE GROUND AT THE SAME RATE
- HOW CAN THAT BE?
 - HEAVIER OBJECT HAS GREATER GRAVITATIONAL FORCE ($F=MA$)
 - HEAVIER OBJECT IS ALSO HARDER TO ACCELERATE
 - THESE TWO THINGS BALANCE SO THAT ALL OBJECTS FALL AT THE SAME RATE

$m = 1000 \text{ kg}$	$m = 1 \text{ kg}$
	
$F_{\text{grav}} = 10\,000 \text{ N}$	$F_{\text{grav}} = 10 \text{ N}$
$a = \frac{F_{\text{net}}}{m} = \frac{10\,000 \text{ N}}{1000 \text{ kg}}$	$a = \frac{F_{\text{net}}}{m} = \frac{10 \text{ N}}{1 \text{ kg}}$
$a = 10 \text{ m/s/s}$	$a = 10 \text{ m/s/s}$

ACCELERATION DUE TO GRAVITY

- ACCELERATION: RATE THAT VELOCITY CHANGES OVER TIME
- ALL OBJECTS POSITIVELY ACCELERATE TOWARD EARTH AT A RATE OF 9.8 m/s/s (OR 9.8 m/s^2)
 - IN OTHER WORDS, EVERY SECOND THAT AN OBJECT FALLS, IT'S VELOCITY INCREASES BY 9.8 m/s . IT'S SPEEDING UP!

AIR RESISTANCE AND FALLING OBJECTS



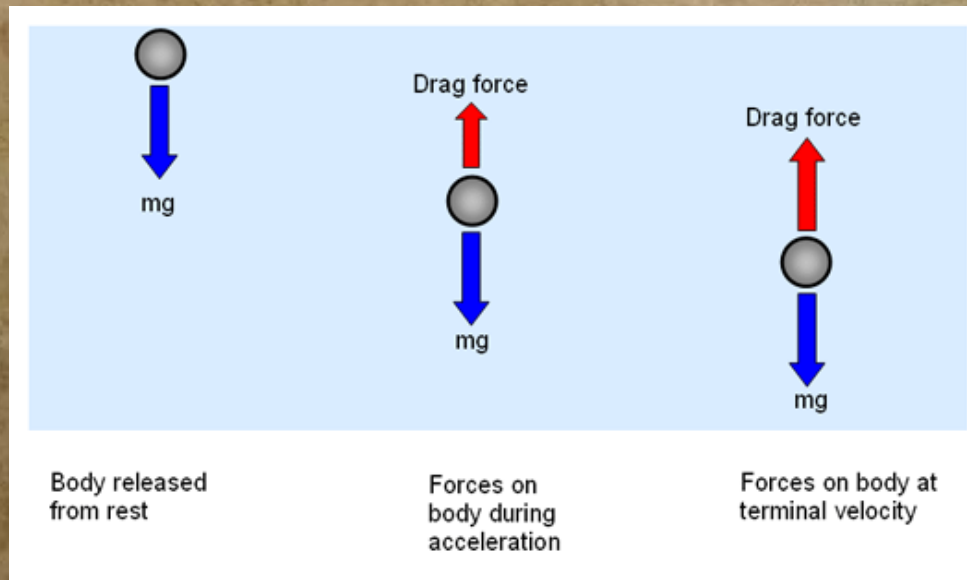
- DROP A FEATHER AND A GOLF BALL. THEY HIT THE GROUND AT DIFFERENT RATES.

WHY??!?!?

- AIR RESISTANCE: THE FORCE THAT OPPOSES THE MOTION OF OBJECTS THROUGH THE AIR
- AMOUNT OF AIR RESISTANCE DEPENDS ON THE SIZE, SHAPE AND SPEED OF THE OBJECT

TERMINAL VELOCITY

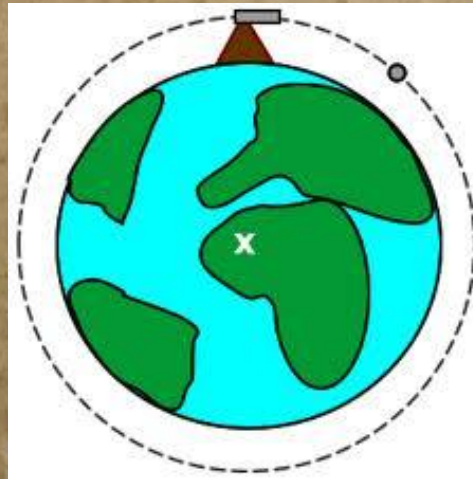
- CONSTANT VELOCITY OF A FALLING OBJECT WHEN THE NET FORCE ON THE OBJECT = 0 NEWTONS
 - AIR RESISTANCE IS EQUAL AND OPPOSITE TO GRAVITY
 - NO ACCELERATION



FREE FALL

- THE MOTION OF A BODY WHEN GRAVITY IS THE ONLY FORCE ACTING ON IT
- OCCURS WHEN THERE IS NO AIR RESISTANCE

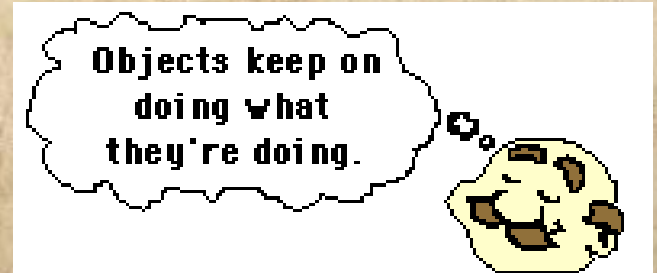
- IN A VACUUM
- IN SPACE



Newton's Cannon
proposes orbiting
objects are
merely in a free
fall

- ORBITING OBJECTS ARE IN FREE FALL

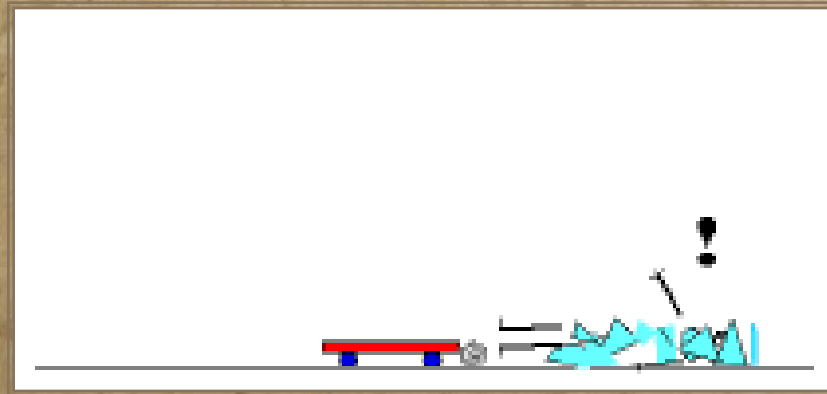
NEWTON'S FIRST LAW



- “AN OBJECT AT REST WILL REMAIN AT REST UNLESS ACTED ON BY AN UNBALANCED FORCE. AN OBJECT IN MOTION CONTINUES IN MOTION WITH THE SAME SPEED AND IN THE SAME DIRECTION UNLESS ACTED UPON BY AN UNBALANCED FORCE.”
- OFTEN CALLED THE LAW OF INERTIA

FIRST LAW EXAMPLE

- CHECK OUT THIS SKATER!



What is the motion in this picture?

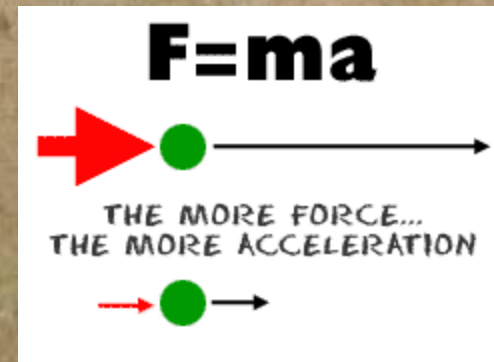
What is the unbalanced force?

What happened to the skater in this picture?



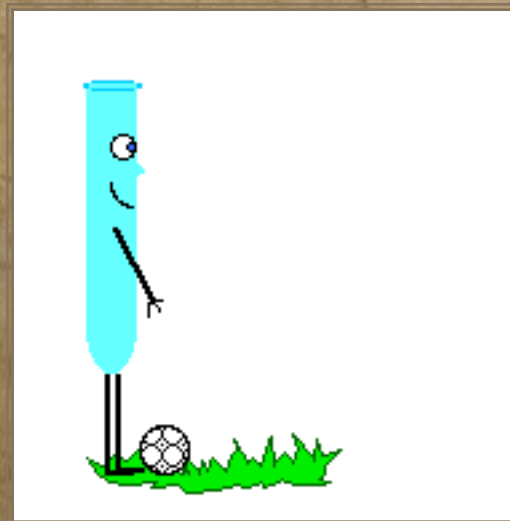
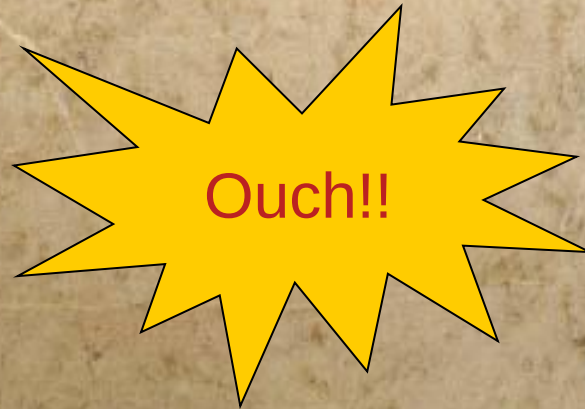
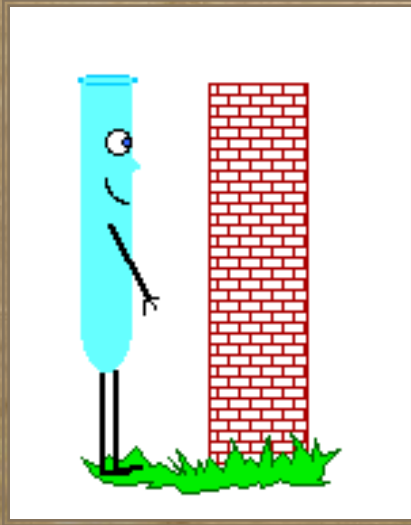
NEWTON'S SECOND LAW

- “ACCELERATION IS PRODUCED WHEN A FORCE ACTS ON A MASS. THE GREATER THE MASS OF THE OBJECT BEING ACCELERATED, THE GREATER THE AMOUNT OF FORCE NEEDED TO ACCELERATE THE OBJECT.”



- WHAT DOES THAT MEAN?
 - HEAVIER OBJECTS REQUIRE MORE FORCE TO MOVE THE SAME DISTANCE AS LIGHTER OBJECTS

SECOND LAW EXAMPLE



SECOND LAW EQUATION

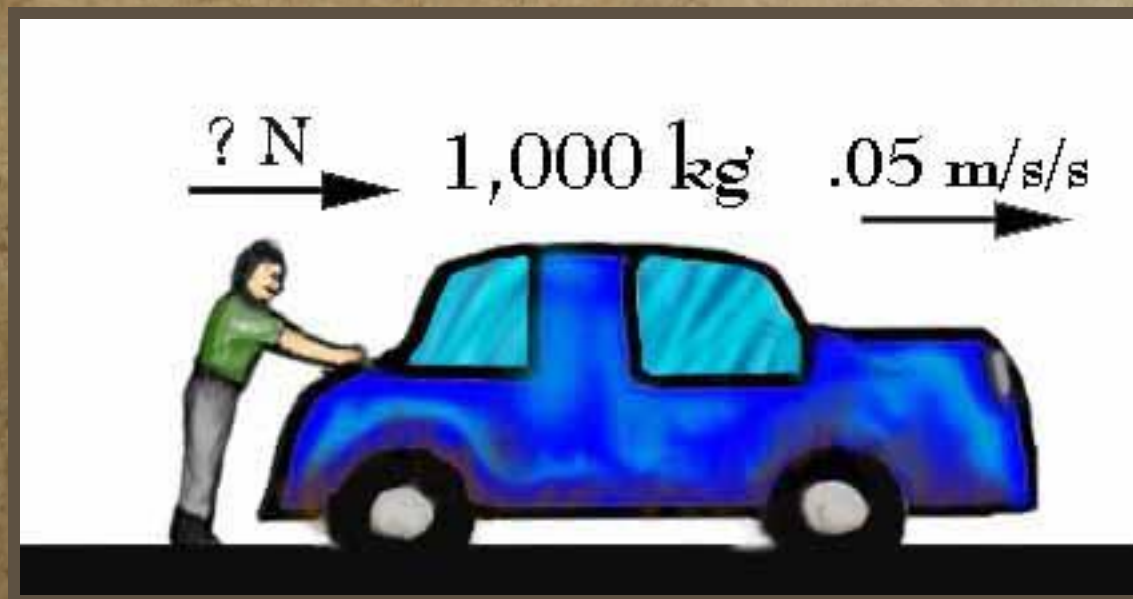
- THE SECOND LAW GIVES US AN EXACT RELATIONSHIP BETWEEN FORCE, MASS AND ACCELERATION. IT CAN BE EXPRESSED AS THE EQUATION BELOW:

$$\underline{\mathbf{F = ma}}$$

FORCE EQUALS THE OBJECT'S MASS, TIMES
THE ACCELERATION OF THAT OBJECT.

MIKE'S DILEMMA

MIKE'S CAR IS OUT OF GAS. IF MIKE WANTS TO PUSH THE CAR TO A GAS STATION AT A RATE OF 0.5 m/s/s , HOW MUCH FORCE DOES HE NEED TO APPLY TO THE 1000 kg CAR?



SOLVING MIKE'S PROBLEM

USING OUR EQUATION:

$$F = ma$$

FORCE IS OUR UNKNOWN VARIABLE

MASS = 1 000 KG

ACCELERATION = 0.05 M/S/S

FORCE = 1 000 KG X 0.05 M/S/S
= 50 NEWTONS!

NEWTON'S THIRD LAW



- “FOR EVERY ACTION, THERE IS AN EQUAL AND OPPOSITE RE-ACTION”

- WHAT DOES THAT MEAN???

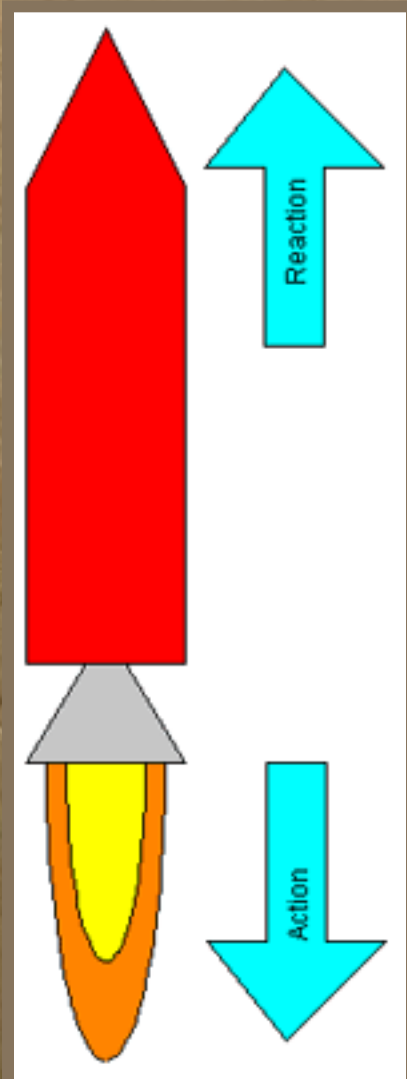
- FOR EVERY FORCE, THERE IS A REACTION FORCE THAT IS EQUAL IN SIZE, BUT IN THE OPPOSITE DIRECTION

OR IN OTHER WORDS...

- WHENEVER AN OBJECT PUSHES ANOTHER OBJECT, IT GETS PUSHED BACK IN THE OPPOSE DIRECTION EQUALLY HARD



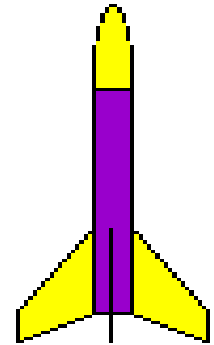
THIRD LAW EXAMPLE



- THE ROCKET'S ACTION IS TO PUSH DOWN ON THE GROUND WITH THE FORCE OF ITS POWERFUL ENGINES
- THE REACTION IS THAT THE GROUND PUSHES THE ROCKET UPWARDS WITH AN EQUAL FORCE

LAWS OF MOTION SUMMARY

- 1ST LAW: AN OBJECT IN MOTION WILL STAY IN MOTION UNLESS ACTED ON BY ANOTHER FORCE (INERTIA)
- 2ND LAW: ACCELERATION IS PRODUCED WHEN A FORCE ACTS ON A MASS ($F=MA$)
- 3RD LAW: FOR EVERY ACTION, THERE IS AN EQUAL AND OPPOSITE REACTION



Up
Up
And Away!

MOMENTUM

LINEAR MOMENTUM

$$P = mv$$

MOMENTUM EQUALS THE
MASS MULTIPLIED BY
THE VELOCITY
OF THE OBJECT

- MOMENTUM DEPENDS ON MASS AND VELOCITY OF AN OBJECT
- THE MORE MOMENTUM AN OBJECT HAS, THE HARDER IT IS TO STOP OR CHANGE THE DIRECTION OF THE OBJECT
- CALCULATED USING:

LAW OF CONSERVATION OF MOMENTUM

- THE MOMENTUM BEFORE A COLLISION IS EQUAL TO THE MOMENTUM AFTER A COLLISION

