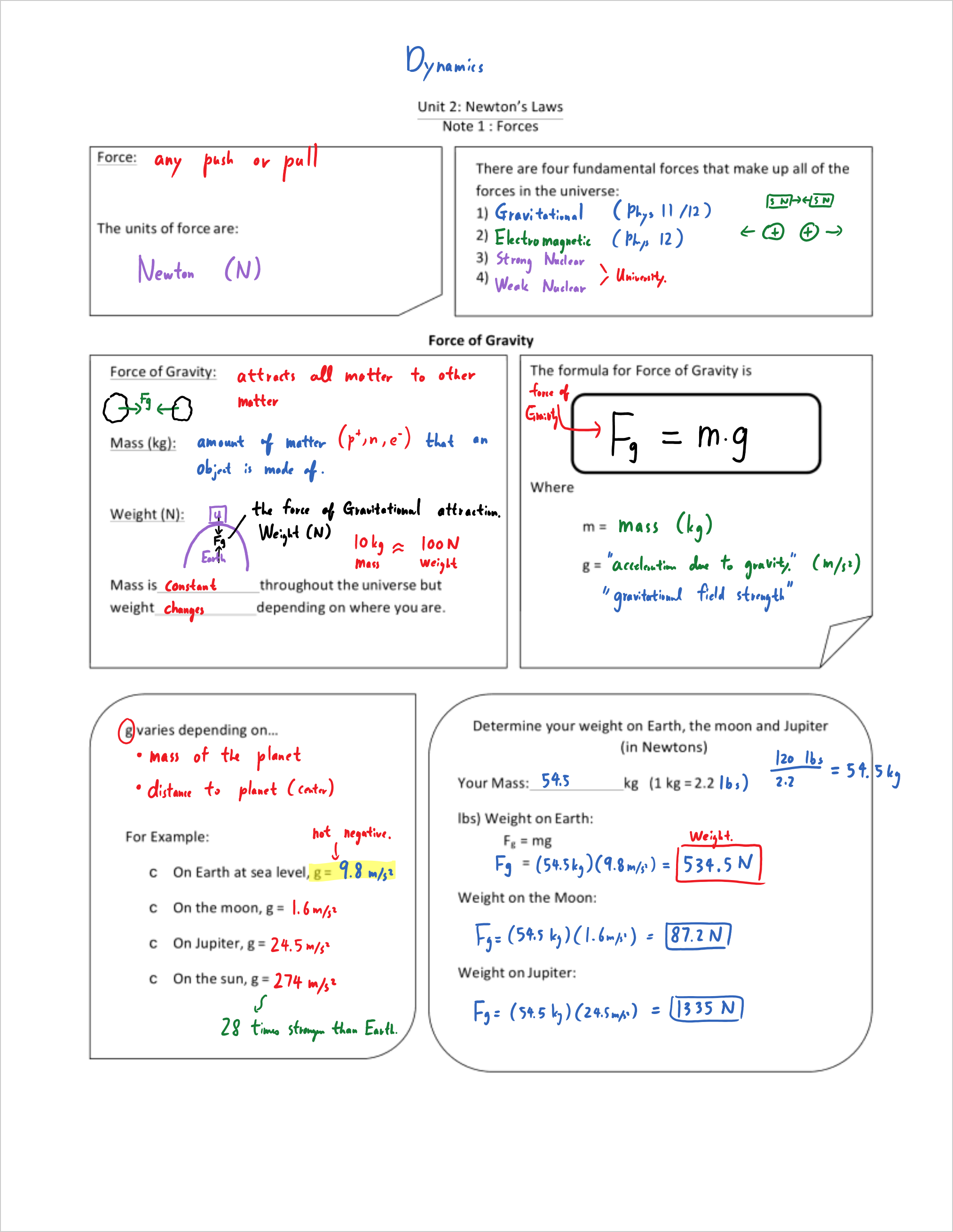
Dynamics Notes Part 1

October 24, 2016 9:25 AM



Dynamics

Unit 2: Newton's Laws

Note 1 : Forces

Force: any push or pull

The units of force are:

Newton (N)

There are four fundamental forces that make up all of the forces in the universe:

1) Gravitational (Phys 11 /12)
2) Electromagnetic (Phys 12)
3) Strong Nuclear
4) Weak Nuclear

} University.

S N → ← S N

← ⊕ ⊕ →

Force of Gravity

Force of Gravity: attracts all matter to other matter

$\rightarrow F_g \leftarrow$

Mass (kg): amount of matter (p^+, n, e^-) that an object is made of.

Weight (N): the force of Gravitational attraction.

Weight (N)

F_g

Earth

10 kg ≈ 100 N
mass weight

Mass is Constant throughout the universe but weight changes depending on where you are.

The formula for Force of Gravity is

force of Gravity

$$\boxed{F_g = m \cdot g}$$

Where

m = mass (kg)

g = "acceleration due to gravity" (m/s²)

"gravitational field strength"

g varies depending on...

- mass of the planet
- distance to planet (center)

For Example:

not negative.

- On Earth at sea level, g = 9.8 m/s²
- On the moon, g = 1.6 m/s²
- On Jupiter, g = 24.5 m/s²
- On the sun, g = 274 m/s²

28 times stronger than Earth.

Determine your weight on Earth, the moon and Jupiter (in Newtons)

Your Mass: 54.5 kg (1 kg = 2.2 lbs)

$\frac{120 \text{ lbs}}{2.2} = 54.5 \text{ kg}$

lbs) Weight on Earth:

$F_g = mg$

$F_g = (54.5\text{kg})(9.8\text{m/s}^2) = \boxed{534.5\text{ N}}$ Weight.

Weight on the Moon:

$F_g = (54.5\text{ kg})(1.6\text{m/s}^2) = \boxed{87.2\text{ N}}$

Weight on Jupiter:

$F_g = (54.5\text{ kg})(24.5\text{m/s}^2) = \boxed{1335\text{ N}}$

Activity:
Jumping on the Moon

Purpose: To determine how high you could jump on the surfaces of the Moon and the Sun. Procedure:

1. Have your lab partner measure your best vertical on Earth.
2. Determine the initial velocity of your jump. We will assume that your initial jump velocity will be the same on the Moon and the Sun.
3. Find your vertical and hang time on the moon using an acceleration = $-1.60\ m/s^2$.
4. Find your vertical and hang time on the Sun using an acceleration = $-274\ m/s^2$.

Earth

Kin

Vertical: 30 cm → 0.30 m

$V_i = ?$

$d = 0.3\ m$

$V_f = 0$

$a = -9.8\ m/s^2$

$V_f^2 = V_i^2 + 2ad$

$V_i^2 = V_f^2 - 2ad$

$V_i = \sqrt{\cancel{V_f^2} - 2ad}$

$V_i = +2.42\ m/s$

Vo = 2.42 m/s

V_i

Moon

~~Vertical:~~

$V_i = 2.42\ m/s$

$a_{moon} = -1.6\ m/s^2$

$d_{max} = ?$

$V_f = 0$

$t = ?$

$V_f = V_i + at$

$t = \frac{V_f - V_i}{a}$

dmax = 1.83 m

t = $\boxed{1.5\ s}$

Sun

~~Vertical:~~

$a_{sun} = -274\ m/s^2$

dmax = 0.0106 m $\xrightarrow{\times 100}$ $\boxed{1.06\ cm}$

t = ___________

A Quick Aside on G-Forces

"G-forces" are actually a measurement of *acceleration* experienced by an object. It is related to the supporting reaction force that an object experiences due to acceleration. While at rest on Earth you are experiencing 1 *g*.

$$1\ g = 9.80\ m/s^2$$

For Example:

A car accelerates at 4.9 m/s², how many g's is that? $\frac{4.9}{9.8} = \frac{1}{2}g = \boxed{0.5g}$

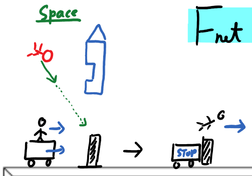
During lift-off a shuttle will accelerate at 28 m/s². How many g's are experienced by the astronaut?

$28\ m/s^2 / 9.8\ m/s^2 = \boxed{2.9\ g}$

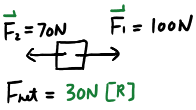
A normal human can withstand 4.0 g's, while a fighter pilot can withstand up to 9.0 g's. What acceleration would cause each to pass out?

Normal Human : $4.0 \times (9.8\ m/s^2) = \boxed{39.2\ m/s^2}$

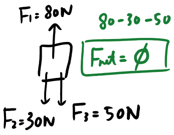
pilot : $9 \times 9.8\ m/s^2 = \boxed{88.2\ m/s^2}$



F_{net} = Sum of all Forces



F_{net} = 30N [R]



80 - 30 - 50

$\boxed{F_{net} = 0}$

Unit 4: Newton's Laws
Newton's 1st Law

Newton's 1st Law:

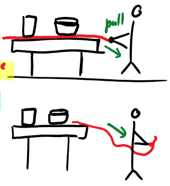
An object in motion will... stay in motion

and an object at rest will... stay at rest

unless... acted upon by an external net Force

This is also referred to as the Law of Inertia.

Inertia: how difficult it is to change an object's motion.



Imagine that you are racing around a track on a go-kart. List *three* times when you notice your *inertia*.

1) Stopping
2) turning
3) Starting

Another way of thinking of Newton's 1st Law is that if there is no net force on an object then it will stay at a constant velocity.

If it is not moving then it has a constant velocity of zero!!!

Ex. Imagine a book sitting on a table. There is a force of gravity pulling down on the book, but there is also a supporting (normal) force pushing up on the book.

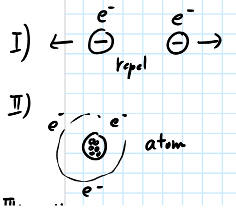
F_N ← normal Force.

↳ in Science normal = ⊾90°

Ex. If I drop the book from 2 m, there is only a downwards, gravitational force acting on it. Now that the forces on it are **unbalanced**, what does the book do?

drop

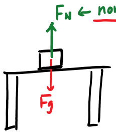
Accelerate



force of gravity pulling down on the book, but there is also a supporting (normal) force pushing up on the book.

F_N ← normal Force.

↳ in Science, normal = $\perp 90°$

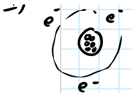


"F_N always $\perp$ to the surface"

downwards, gravitational force acting on it. Now that the forces on it are **unbalanced**, what does the book do?

drop

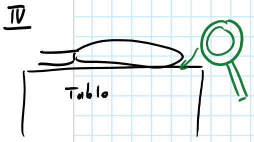
Accelerates



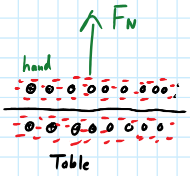
atom

III) all matter → atoms

IV



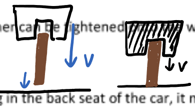
(e^-, e^- repel)



Examples:

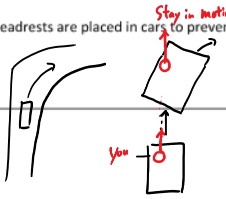
1) While riding a skateboard (or chuckwagon or unicycle, whatever), you fly forward off the board when hitting a curb or rock or other object which abruptly halts the motion of the skateboard.

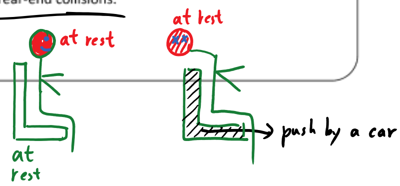
2) The head of a hammer can be tightened onto the wooden handle by banging the **bottom** of the handle against a hard surface.



3) While you are sitting in the back seat of the car, it makes a hard right turn. You squish your sister against the side door (CORNERS!!!).

4) Headrests are placed in cars to prevent whiplash injuries during rear-end collisions.





Newton's 1st Law: If $F_{net} = 0$, an object at rest will stay at rest
an object in motion will stay in motion.

Unit 4: Newton's Laws

Newton's 2nd Law

Newton's 2nd Law: An unbalanced force results in an acceleration.

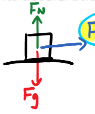
Stated as a formula:

"F_{net}" and "a" have the same direction!!

$$\vec{F}_{net} = m\vec{a}$$

Note that... unit $N = kg \cdot m/s^2$

Ex. A 5.0 kg block is pushed to the right along a frictionless track with a force of 10.0 N. What is its acceleration?



$F = 10N$

$F_{net} = F$

$ma = 10N$

$5kg\ a = 10\ N$

$\boxed{a = 2\ m/s^2\ [\text{Right}]}$

Ex. A 650 kg car accelerates at 4.0 m/s² south. What is the net force acting on it?

$F_{net} = ma$

$= 650kg \cdot 4m/s^2$

$= 2600\ N\ [\text{South}]$

Ex: A 1500 kg ice cream truck accelerates from rest to a top speed of 45 km/h in 8.0 s. What was the net force acting on the truck?

$a = ?$ $V_i = 0$ $t = 8$ $V_f = 12.5\ m/s$

$V_f = V_i + at$

$a = \frac{V_f - V_i}{t}$

$a = \frac{12.5 - 0}{8} = 1.5625\ m/s^2$

$F_{net} = ma$

$F_{net} = (1500)(1.5625)$

$F_{net} = 2343.75\ N$

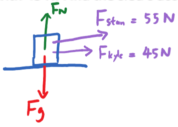
To find F_{net} when two forces work together ...

add them up!!

To find F_{net} when many forces act on an object:

F_{net} = Winners − Losers

Ex. Stan and Kyle are pushing a 75 kg sled along a frictionless ice rink. Stan pushes with 55 N and Kyle pushes with 45 N. Find the sled's acceleration.



$F_{net} = F_{Stan} + F_{Kyle}$

⇓

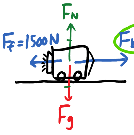
$ma = 55N + 45N$

$(75kg)\ a = 100N$

$\boxed{a = 1.33\ m/s^2}$

Ex: The Batmobile exerts a force of 8.50x10³ N east, while friction pulls back on it with a force of 1500 N. If it has a mass of 1250 kg, what is its acceleration?

8500 N



win

$F_{Bat} = 8500N$

[W] ⟷ [E]

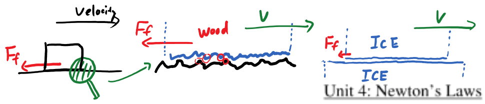
$F_{net} = F_{Bat} - F_f$

⇓

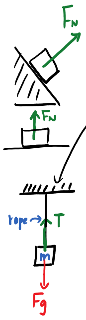
$ma = 8500 - 1500$

$(1250)\ a = 7000$

$\boxed{a = 5.6\ m/s^2\ [\text{East}]}$



Unit 4: Newton's Laws - **FBDs**



Force	Description
Fg	Force of Gravity
Fapp	Applied Force → any Push
Ff	Force of Friction → against motion.
FN	Normal Force → ⊥ to the surface
T	Tension → Force along a rope/wire
FE / Fs	Elastic Force → spring/elastic band.
Fair	Air resistance

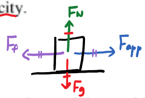
Fapp Friction

Ex 1: A box is pushed across a rough floor at a constant velocity.

a = 0

⇓

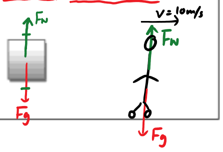
$F_{net} = 0$



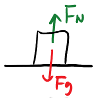
Ex 2: A hockey player glides on frictionless ice at a constant velocity.

⇓

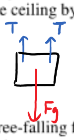
$F_{net} = 0$



1. A book is at rest on a table top.

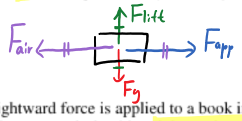


2. A girl is suspended motionless from a bar which hangs from the ceiling by two ropes.

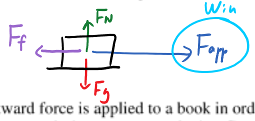


3. An egg is free-falling from a nest in a tree. Neglect air resistance.

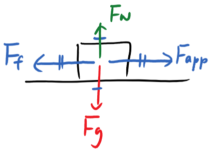
4. A plane flies at a constant velocity (**Note**: there will be an applied force generated by the engines as well as a lift force provided by the wings).



5. A rightward force is applied to a book in order to move it across a desk with a rightward acceleration. Consider frictional forces. Neglect air resistance.



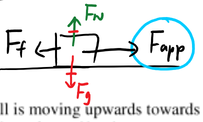
6. A rightward force is applied to a book in order to move it across a desk at constant velocity. Consider frictional forces. Neglect air resistance.



7. A college student rests a backpack upon his shoulder. The pack is suspended motionless by one strap from one shoulder.

8. A skydiver is descending with a constant velocity. Consider air resistance.

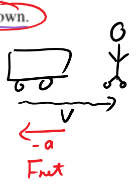
9. A force is applied to the right to drag a sled across loosely-packed snow with a rightward acceleration.

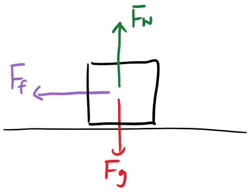


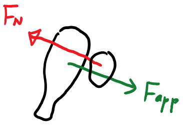
10. A football is moving upwards towards its peak after having been *booted* by the punter.

No Fapp friction → Left

11. A car is coasting to the right and slowing down. Diagram the forces acting upon the car.







Unit 4: Newton's Laws

Newton's 3rd Law

Newton's 3rd Law:

For every action Force there is an equal (in magnitude) but opposite (in direction) reaction Force.

Any interaction involves two forces that we call...

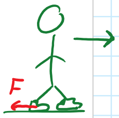
action – rection force pairs.

1) You hit a baseball with a bat.

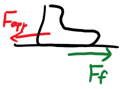
bat hits ball — ball hit bat

2) A sprinter starts running.

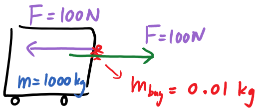
runner pushes ground — ground pushes runner



3) A fish swims through water.



Imagine a bug hitting the windshield of a semi trailer.



What force pair occurs?

truck hit bug – bug hits truck

Which force is bigger?

Same !!

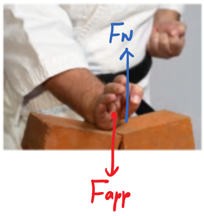
Which object has a greater acceleration?

bug !! $m_{truck} >>>> m_{bug}$.

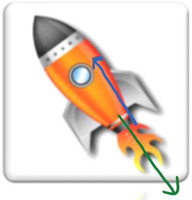
Example 1: Recoil

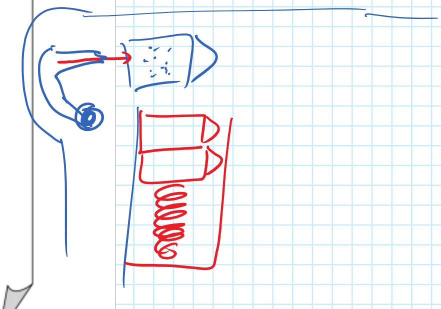
gun pushes bullet — bullet pushes gun !!

Example 2: Bricks



Example 3: Rockets





Quiz on 3 Laws