# How can we describe motion? quantitatively

<u>SI units</u>

grams, meters, seconds, Newtons — $kg \frac{m}{s^2}$

3 Laws - 1. Inertia
2. $F = m\vec{a}$
3. equal/opposite forces on different objects

Weight ≠ Mass
- Weight: nonconstant
- Mass: Constant

Distance, Time

$\frac{\Delta D}{\Delta t}$ = average speed

+ direction

Vectors!

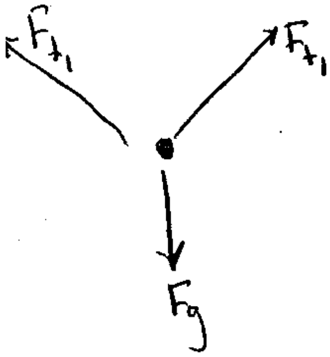
- acceleration ≠ Force, Velocity
- acceleration: $\frac{\Delta v}{\Delta t}$ + direction
- Force: energy + direction
- Velocity: $\frac{\Delta D}{\Delta t}$ + direction

Or for a circle

$\vec{a} = \frac{v^2}{r}$ (uniform circular ~~constant~~ motion)

acceleration points toward center of circle perpendicular to velocity vector

FBD




**Force = $m\vec{a}$**

Can separate into x & y components

$F_t = f_{m_{tx}} + f_{ty}$

$= x\hat{i} + y\hat{j}$

different types of forces
- normal
- weight $mg$
- tension (e.g. string rope)
- Friction — kinetic vs. static
- Spring Force — $F_{sp} = -kx$ (Hooke's Law)

$-k$ = spring constant

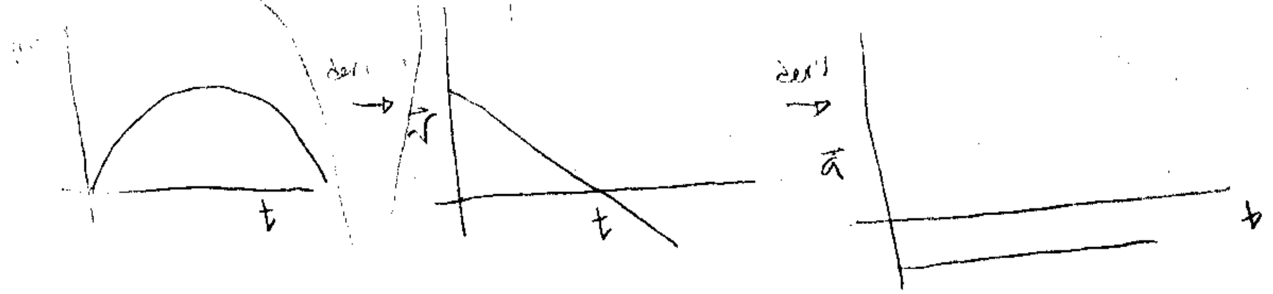

Sir Issac Newton

mass (kg, scalar) — ✗ weight

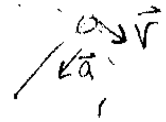
speed (m/s, scalar) → velocity (m/s, vector)

acceleration (vector, $m/s^2$) ← $\Delta t$

Force (vector, N) — $F_w = m \cdot g$




- Uniform circular motion
- units
- friction — always opposes motion
- springs

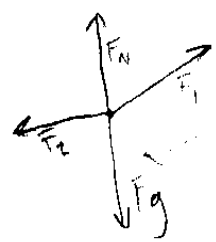



$\vec{a}$ always Δ'ing direction

$F_{sp} = -k\,x$ — stretch [illegible]

Force / spring constant

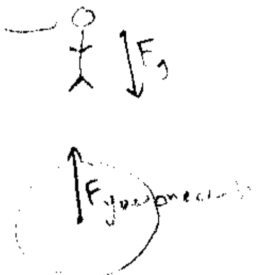
Force diagrams



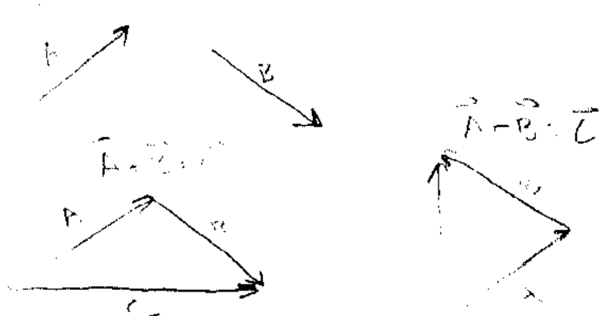

Newtons 1st law - Every action has = opposite [illegible]

2nd law - $F = m \cdot a$

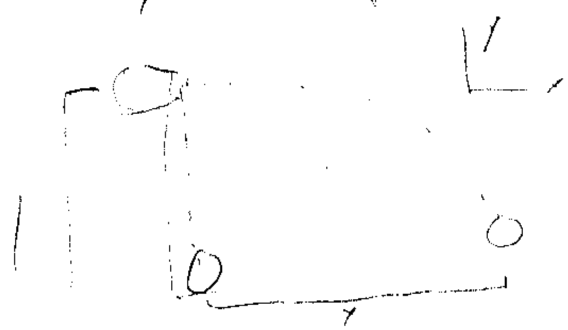
3rd law - Force pairs




Vector arithmetic




x y / motion separate




hit same time ground

# Forces

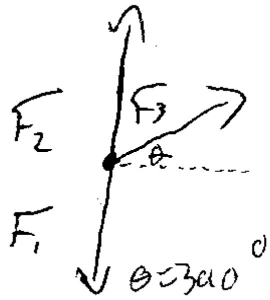
$F = ma$

$F_{net} = ma$

$F_{net} = ma \rightarrow \Sigma F = ma \rightarrow F_1 + F_2 + F_3 = ma$

$\bar{a} = \frac{\Delta V}{\Delta t}$

$\bar{V} = \frac{\Delta x}{\Delta t}$




$F = ma \rightarrow \vec{n} + \vec{F_g} = m\vec{a} \rightarrow \begin{cases} n_x + F_{gx} = ma_x \\ n_y + F_{gy} = ma_y \end{cases}$

$F_w = mg$ where $g = 9.8 \frac{N}{kg}$

$g = 9.81\ m/s^2$

if force is at an angle, then components are needed.

## Friction

$f_k = \mu_k n$

friction forces oppose the direction of motion.

| | x | y |
|---|---|---|
| $F_1$ | 0 | $F_1$ |
| $F_2$ | 0 | $F_1$ |
| $F_3$ | $F_3 \cdot \cos$ | $F_3 \cdot \sin(30)$ |

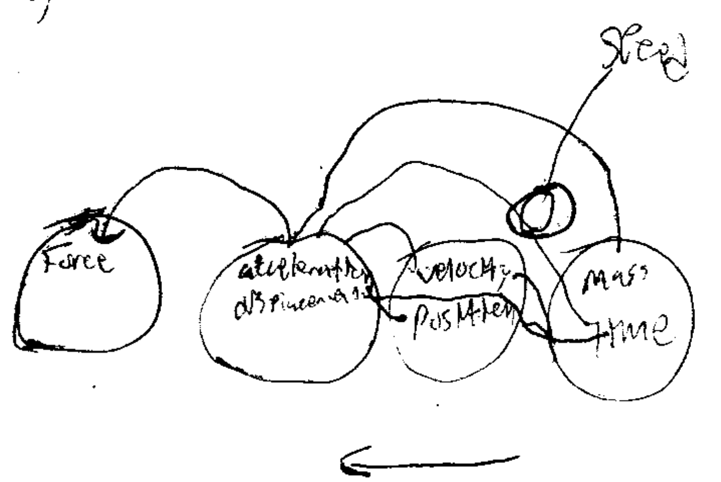
to solve for unknown force, add vector components and solve for unknown.

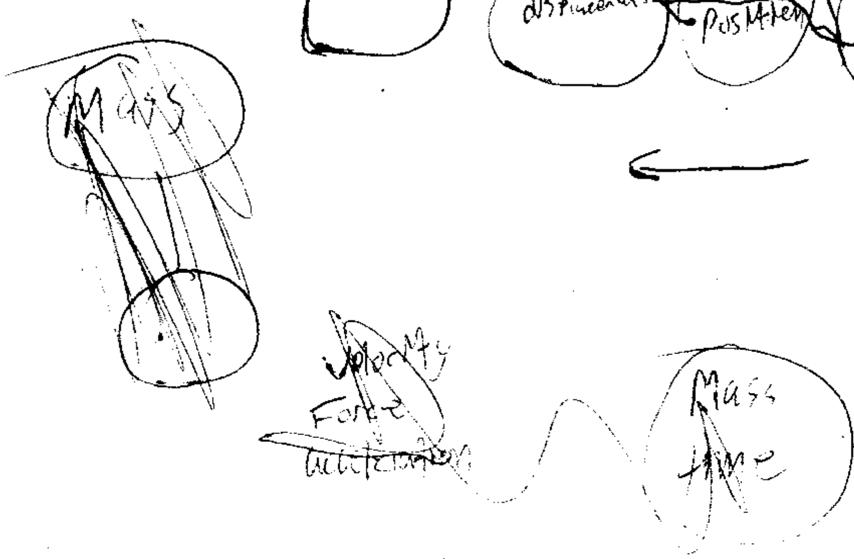
## Forces w/ Uniform Circular Motion

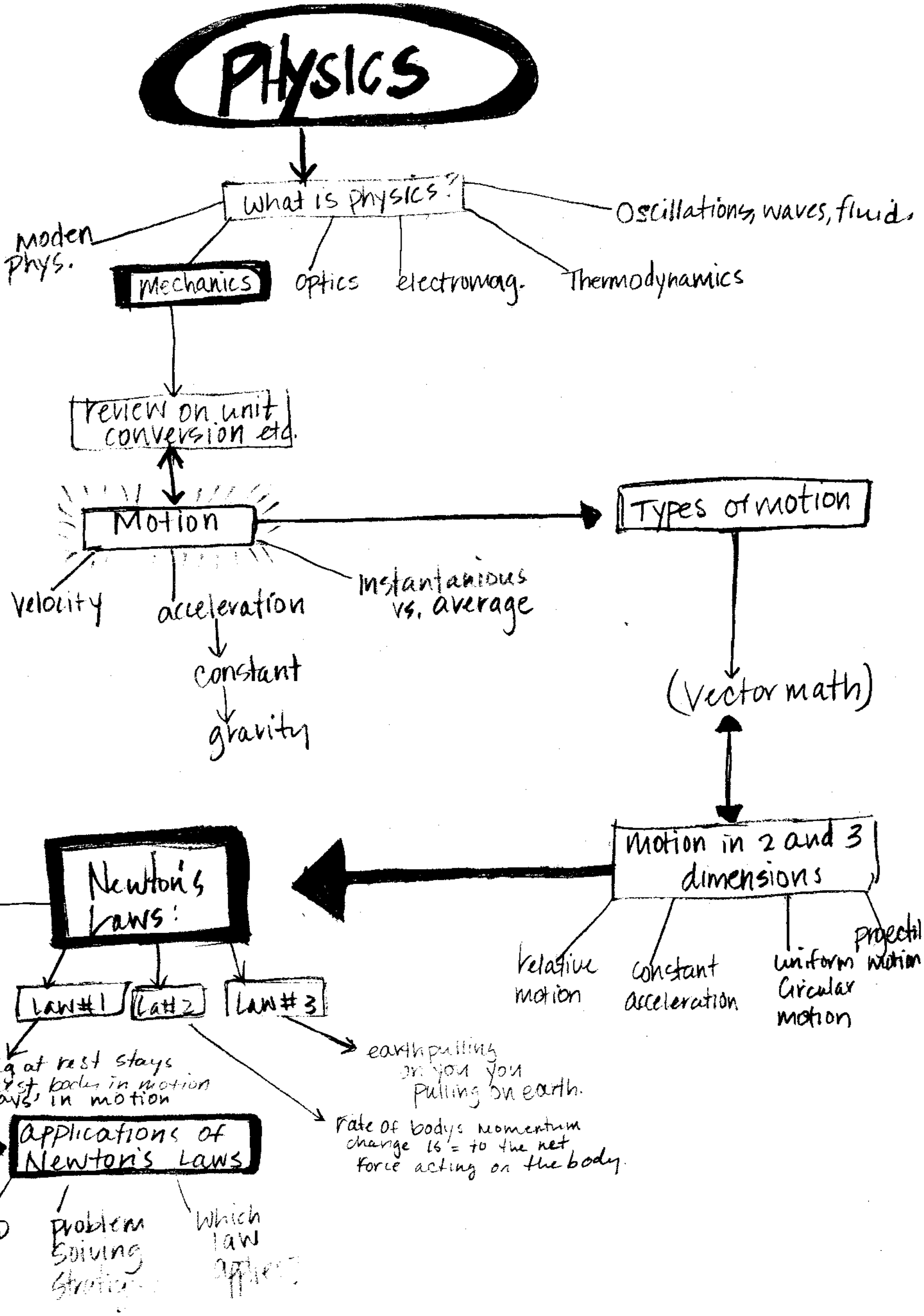
$F_{net} = ma = \frac{mv^2}{r}$

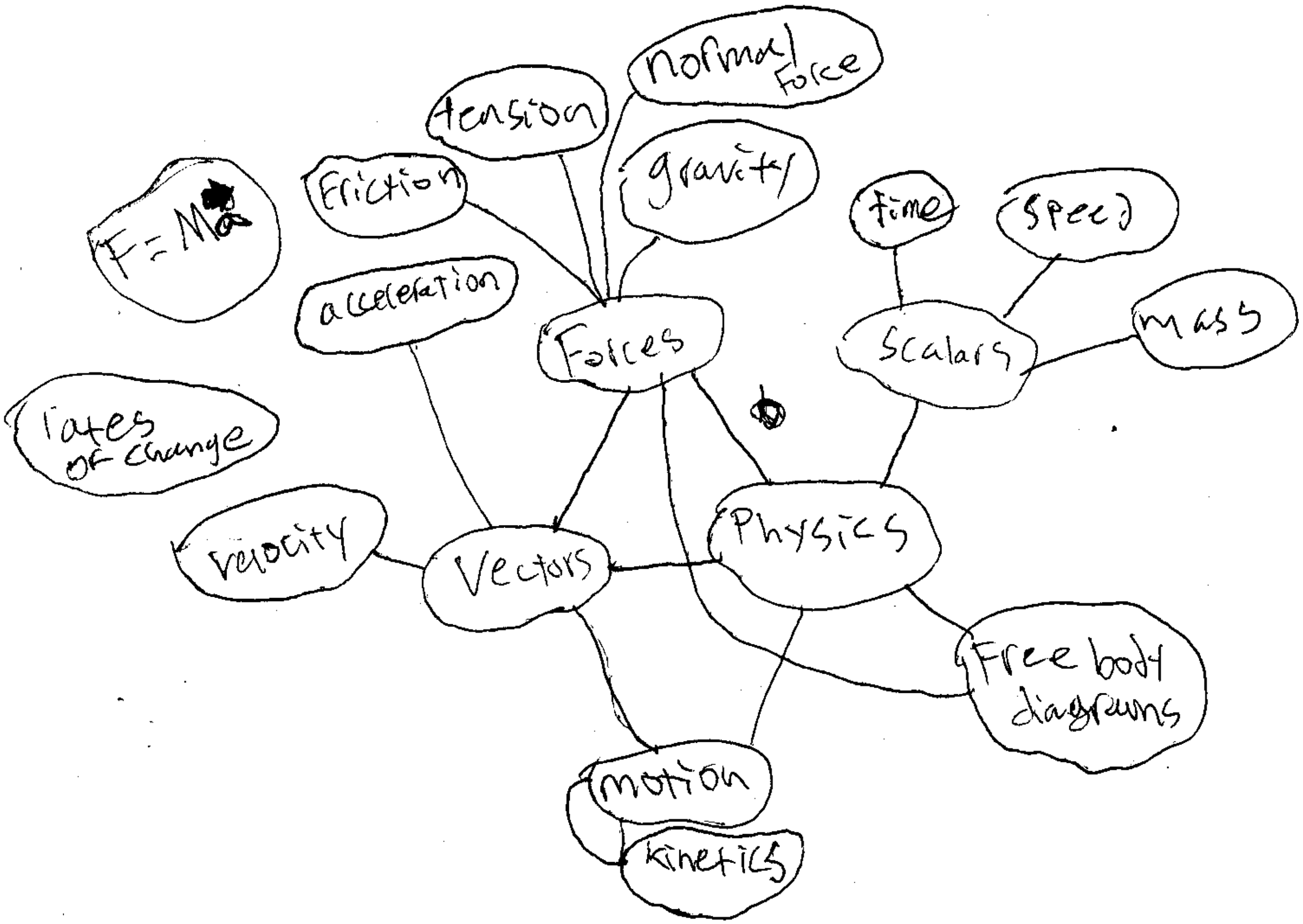
$\Sigma F = ma = \frac{mV^2}{r}$

$F_1 + F_2 = ma = \frac{mv^2}{r}$

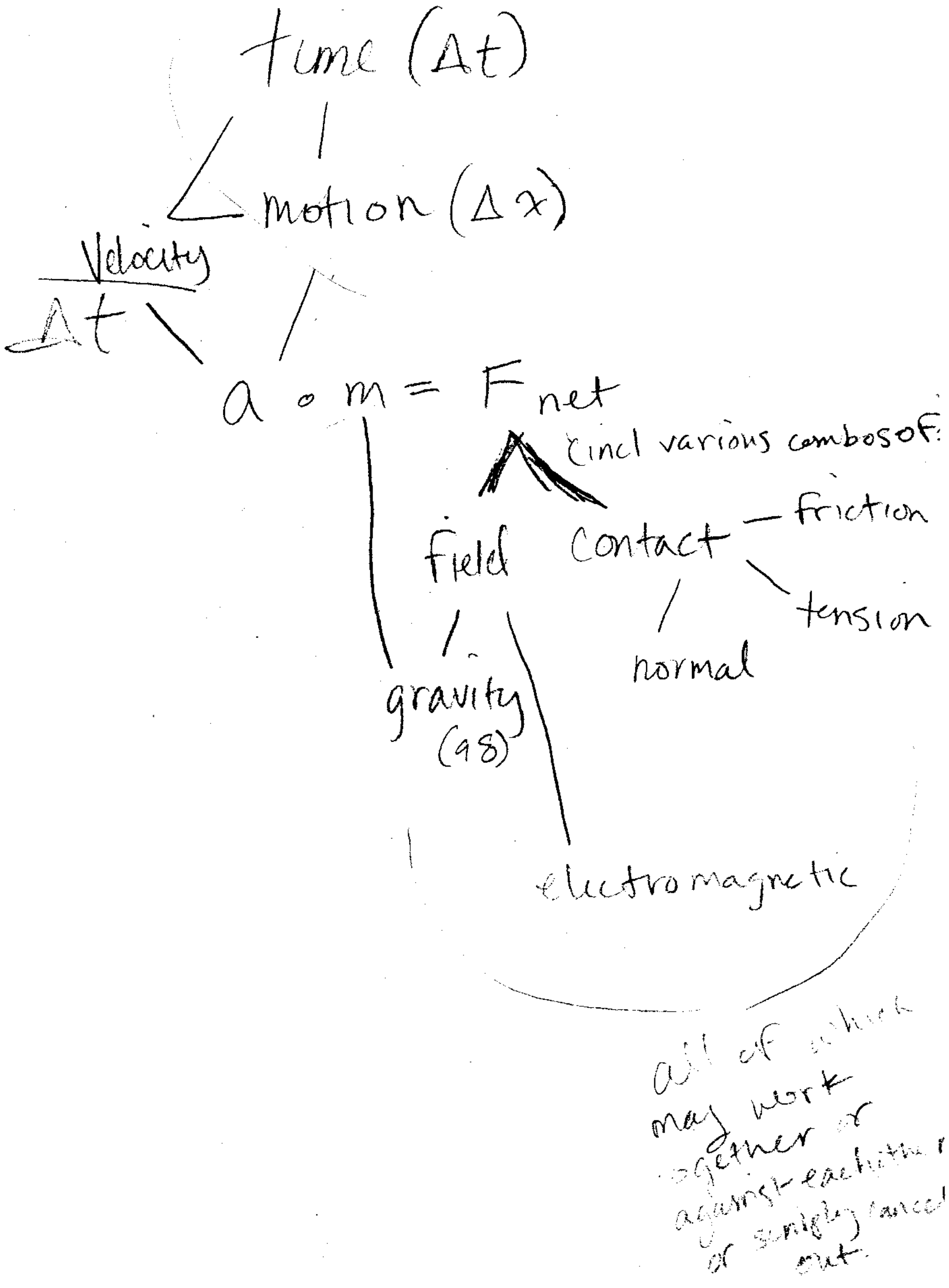


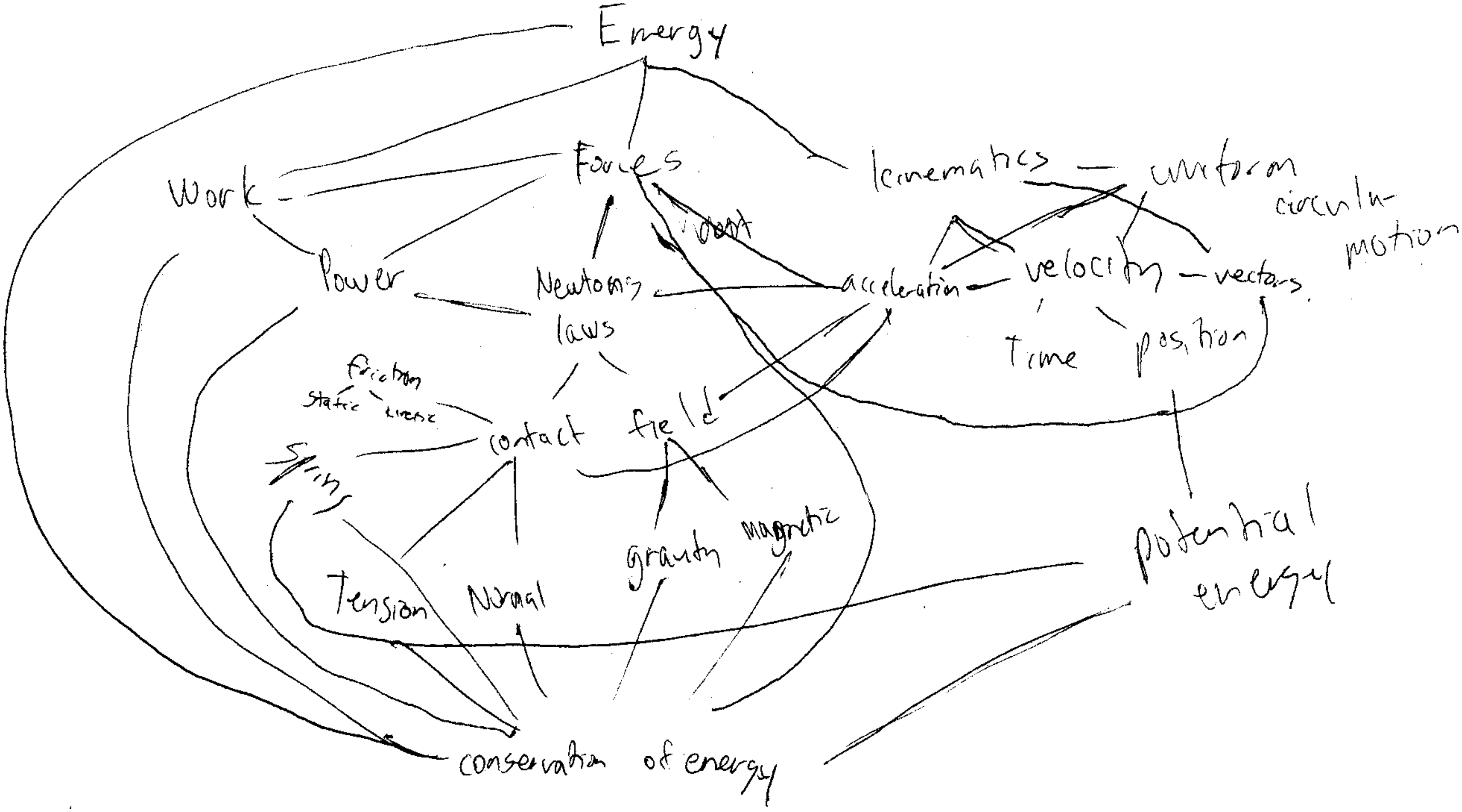

PHYSICS
What is physics?
Moden Phys.
Mechanics
Optics
electromag.
Thermodynamics
Oscillations, waves, fluid.
review on unit conversion etc.
Motion
velocity
acceleration
constant
gravity
instantanious vs. average
Types of motion
(Vector math)
motion in 2 and 3 dimensions
relative motion
constant acceleration
uniform Circular motion
projectile motion
Newton's Laws:
Law#1
La#2
Law#3
body at rest stays at rest, body in motion stays in motion
rate of bodys momentum change is = to the net force acting on the body.
earth pulling on you you pulling on earth.
applications of Newton's Laws
FBD
Problem Solving
Which law



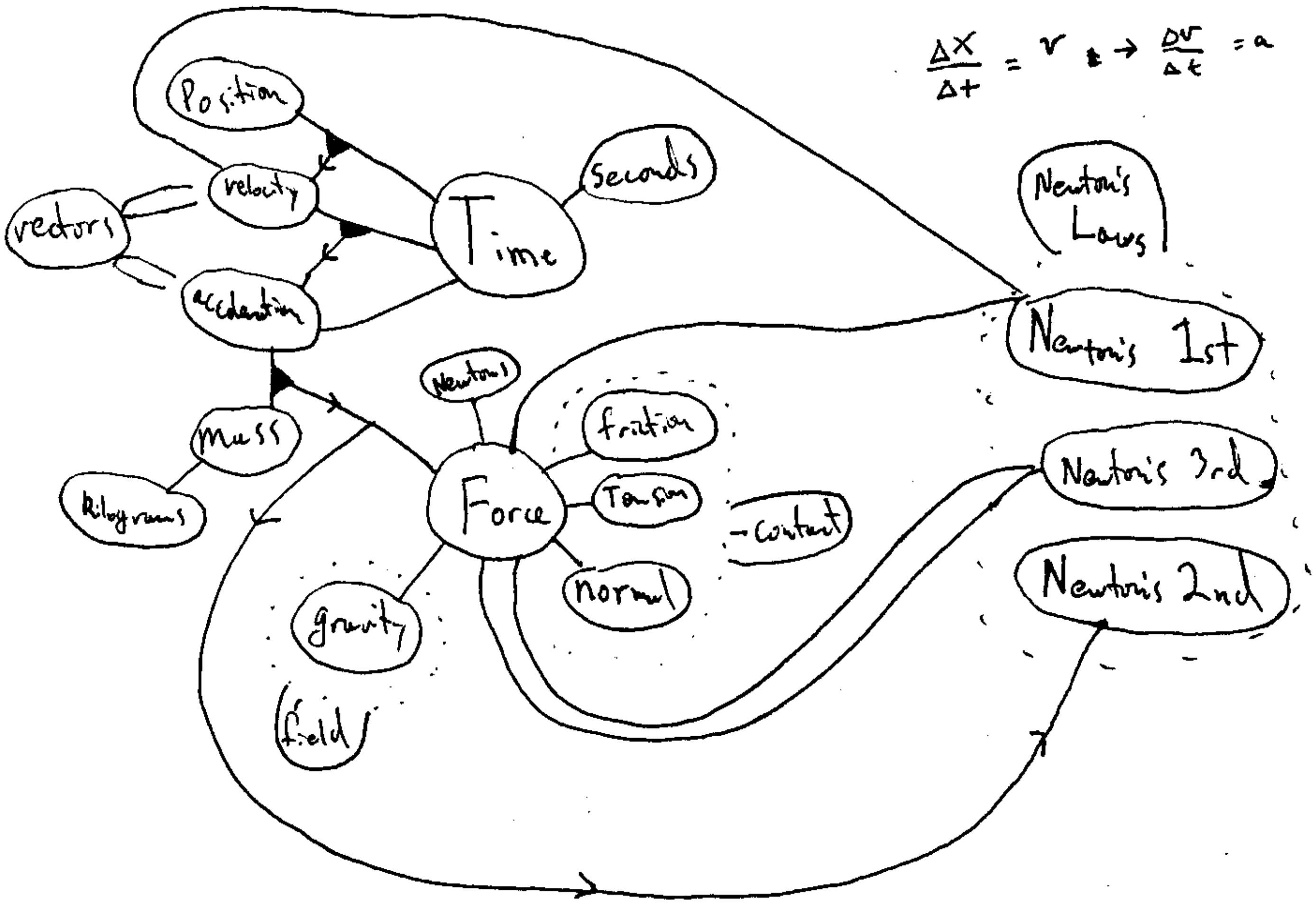
normal Force
tension
Friction
gravity
F=Ma
acceleration
Forces
time
speed
Scalars
mass
rates of change
Physics
velocity
Vectors
Free body diagrams
motion
kinetics



time (Δt)
motion (Δx)
Velocity
Δt
a · m = F net
(incl various combos of:
field
contact
friction
tension
normal
gravity
(9.8)
electromagnetic
all of which may work together or against each other or simply cancel out.


Energy
Work
Forces
kinematics
uniform circular motion
Power
Newton's laws
acceleration
velocity
vectors
Time
position
friction
static
kinetic
contact
field
Springs
gravity
magnetic
Tension
Normal
potential energy
conservation of energy

$$\frac{\Delta x}{\Delta t} = v \rightarrow \frac{\Delta v}{\Delta t} = a \rightarrow am = F$$



# MOTION


**Position** (Static)

↓ $\Delta$ Position

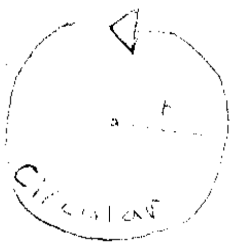
**Displacement** (change)

↓ $\frac{\Delta \text{ position}}{\Delta \text{ time}}$

**Velocity** (rate of change)

↓ $\frac{\Delta \text{ Velocity}}{\Delta \text{ time}}$

**Acceleration** (rate of rate of change)




$a = \frac{(\text{Velocity})^2}{\text{radius}}$

# FORCE

**Momentum** (mass)(Velocity)

↓ $\frac{\Delta \text{ momentum}}{\Delta \text{ time}}$

**Force!** (mass)(acceleration)

Newtons = Kg · m/s²

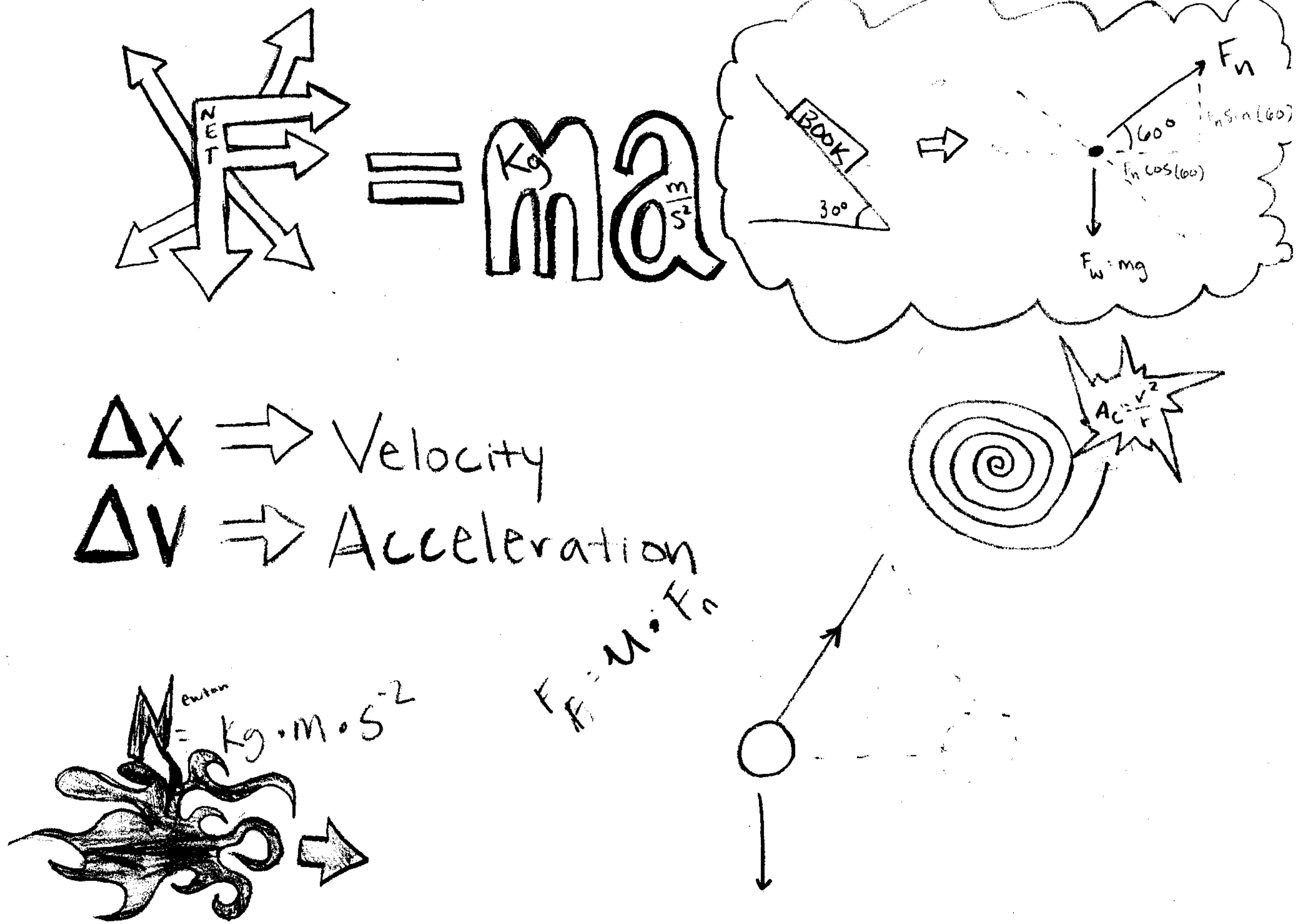
$1N = 1\,kg \cdot 1\,\frac{m}{s^2}$

☆ Special Cases!

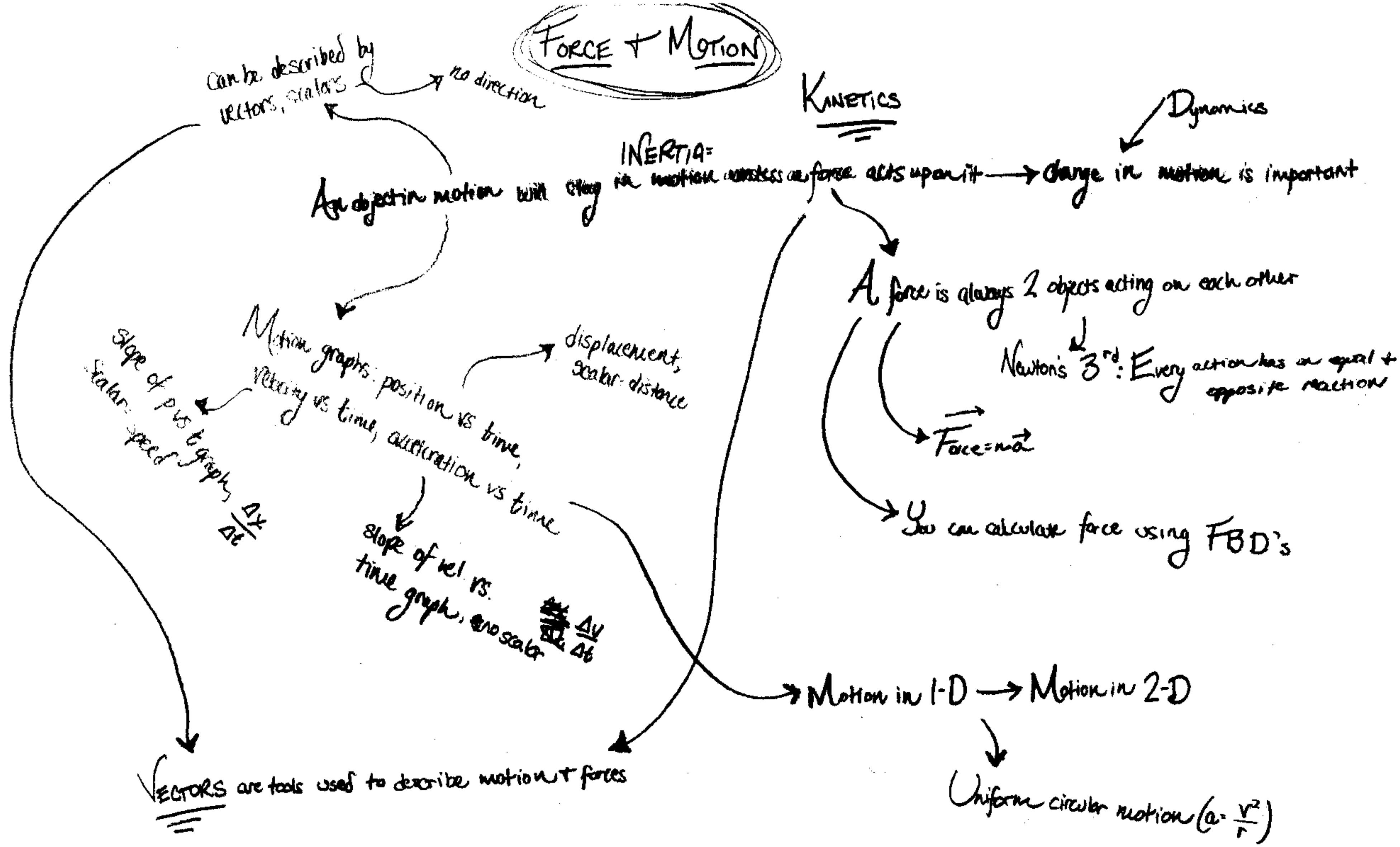
$\vec{\text{Weight}} = \text{Mass} \cdot \vec{g}$ (gravitational acceleration)

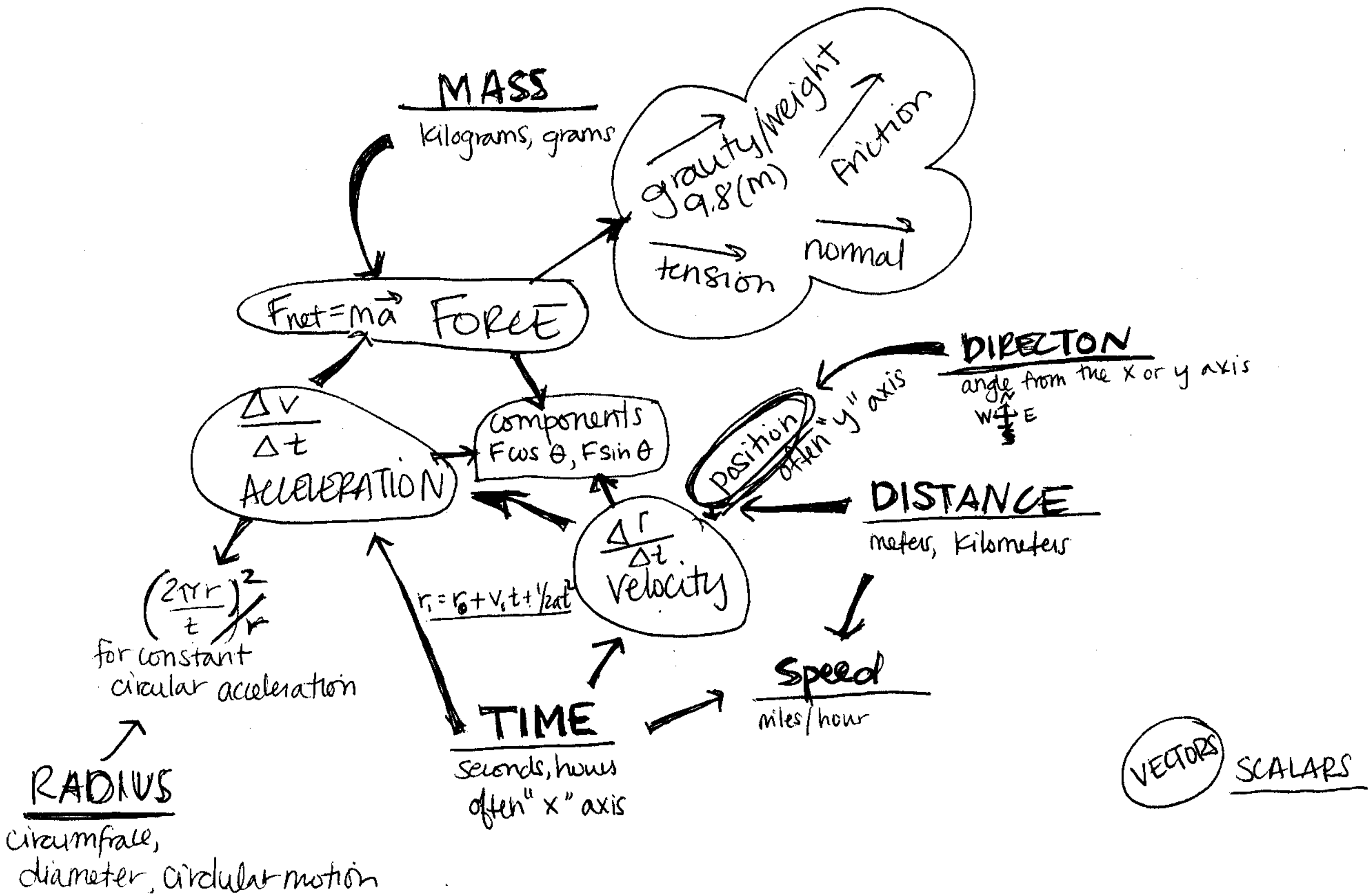
$\vec{F}_{spring} = -K \cdot X$

(K: spring constant in N/m) (X: stretch in m)



NET
F = ma
Kg
m/s²
BOOK
30°
60°
Fn
Fn sin(60)
Fn cos(60)
Fw = mg
Ac = v²/r
Δx ⇒ Velocity
Δv ⇒ Acceleration
Ffr = μ • Fn
Newton = Kg • m • s⁻²


Force + Motion
Can be described by vectors, scalars
no direction
Kinetics
Dynamics
INERTIA=
An object in motion will stay in motion unless a force acts upon it
change in motion is important
A force is always 2 objects acting on each other
Newton's 3rd: Every action has an equal + opposite reaction
Force = ma
You can calculate force using FBD's
Motion graphs: position vs time, velocity vs time, acceleration vs time
displacement, scalar: distance
slope of p vs t graph, Δx/Δt
scalar: speed
slope of vel vs. time graph, no scalar Δv/Δt
Motion in 1-D
Motion in 2-D
Uniform circular motion (a = v²/r)
VECTORS are tools used to describe motion + forces


MASS
kilograms, grams
gravity/weight
9.8(m)
friction
tension
normal
Fnet=ma⃗ FORCE
DIRECTON
angle from the x or y axis
W E S
position
often "y" axis
components
Fcos θ, Fsin θ
Δv / Δt
ACCELERATION
DISTANCE
meters, kilometers
Δr / Δt
Velocity
r1 = r0 + v1t + ½at²
(2πr / t)² / r
for constant
circular acceleration
Speed
miles/hour
TIME
seconds, hours
often "x" axis
RADIUS
circumfrace,
diameter, circular motion
VECTORS
SCALARS

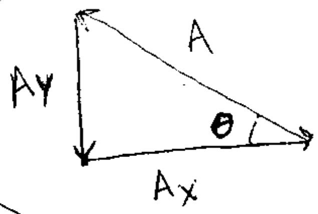
① What is the question asking me? | Force + motion |

② How do I start to solve?

List your components + Draw a vector diagram (or Force diagram)

Components can be:

- *Angles
- *directions
- *mass
- *acceleration / Speed




$A_x = A\cos\theta$

$A_y = A\sin\theta$

$|A| = \sqrt{A_x^2 + A_y^2}$

$\vec{F}_g$ (gravity) $= 9.8\,m/s^2 \cdot$ mass

*Near the surface of Earth.

$\vec{F}_{net} = (\text{mass})(\text{acceleration})$

$\vec{F}_f$ = frictional force (varies)

$\vec{F}_{sp} = -kx$ (spring force)

-k is spring constant, x = how much spring expanded.

Kind of like tension force.

$\vec{a} = \frac{\Delta V}{\Delta t}$ → usually in $m/s^2$

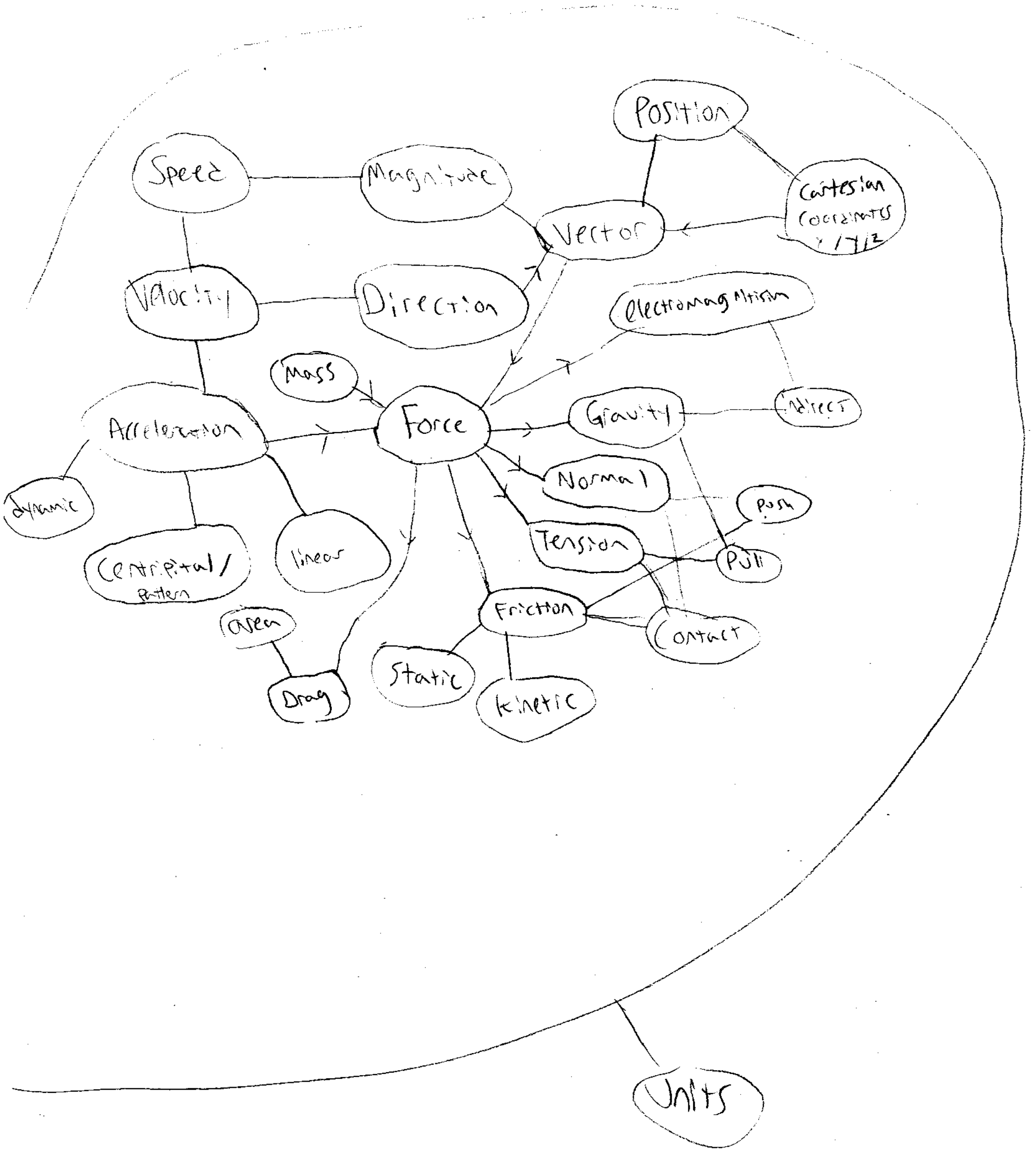
acceleration = $\frac{\text{change in velocity}}{\text{change in time}}$

$\vec{V} = \frac{\Delta X}{\Delta t}$ (or y or x or whatever)

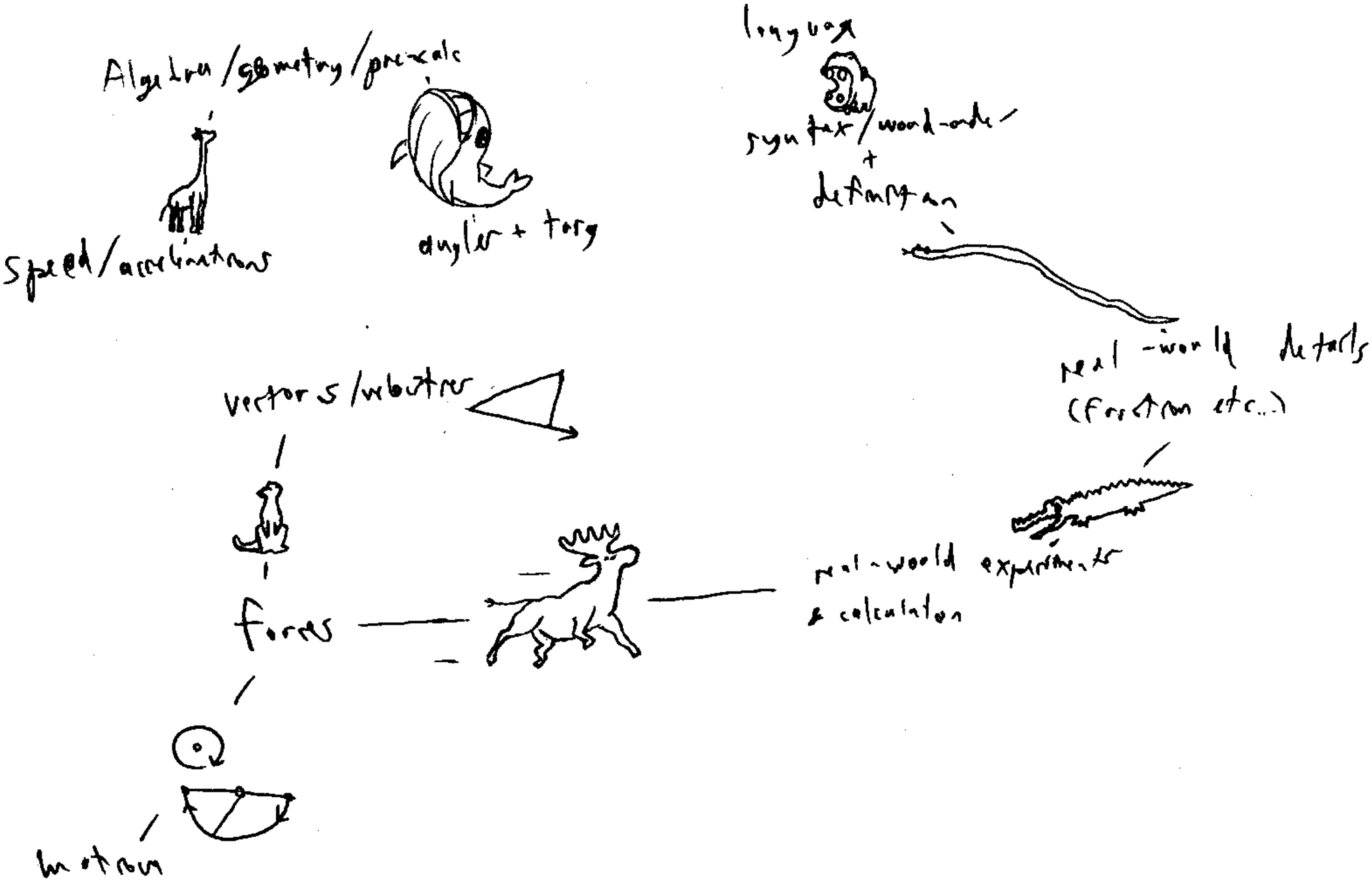
Velocity = $\frac{\text{change in position}}{\text{change in time}}$ → usually in m/s.

(Sometimes acceleration/velocity is not given. We must calculate it!)

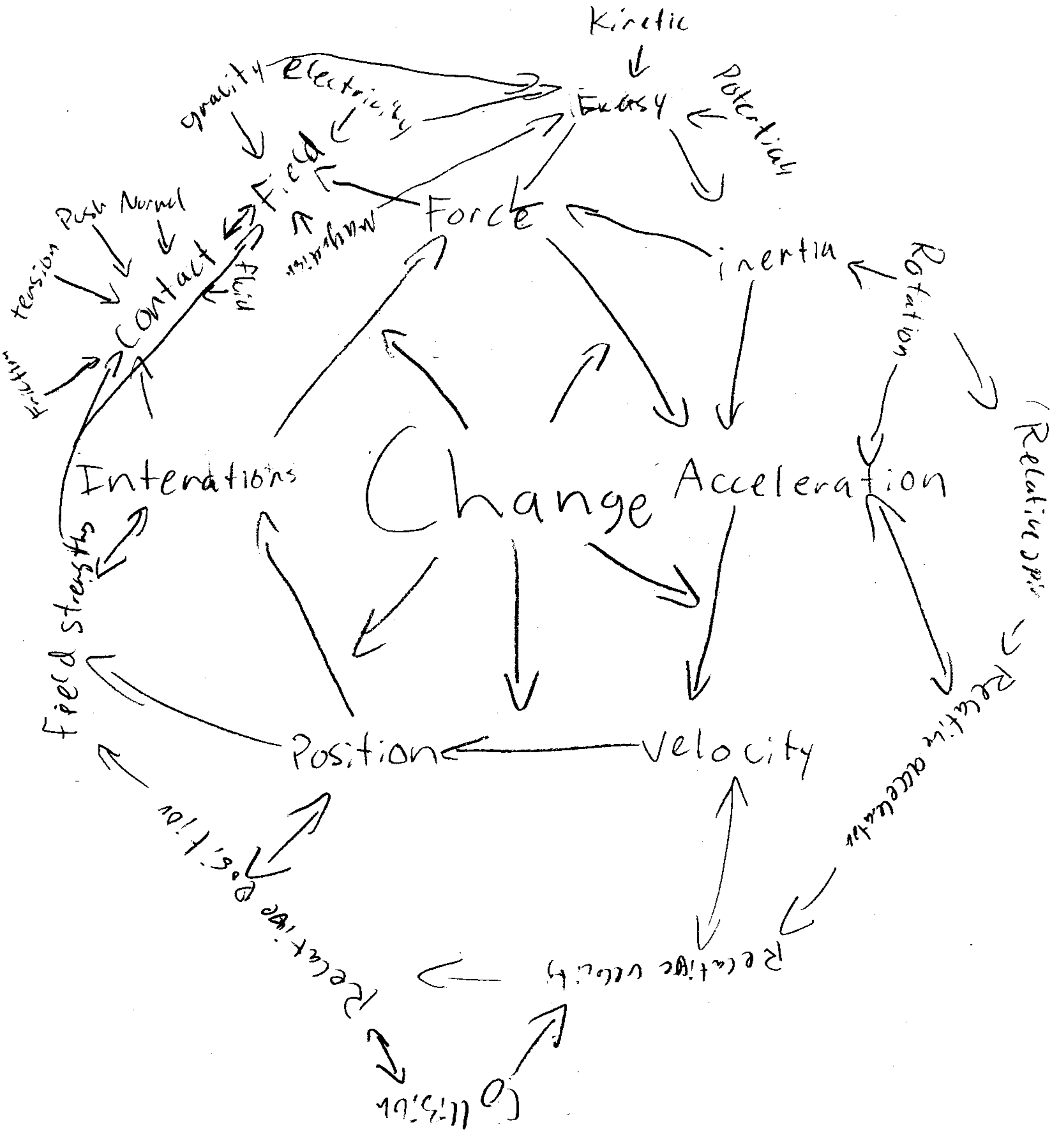
③ Does my answer make sense?!

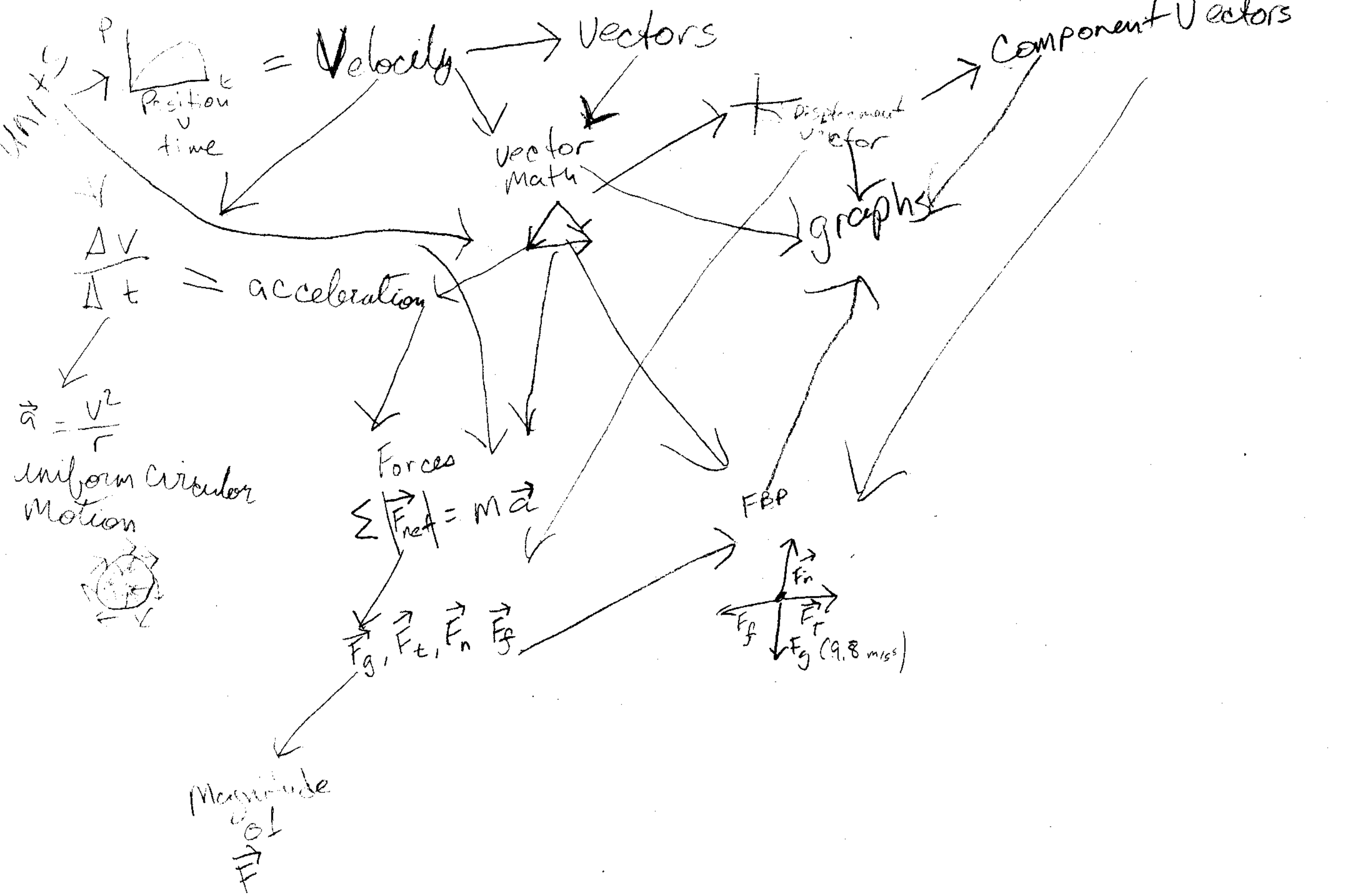


Position
Speed
Magnitude
Vector
Cartesian coordinates x/y/z
Velocity
Direction
Electromagnetism
Mass
Force
Acceleration
Gravity
Indirect
Normal
dynamic
Push
Tension
Pull
Centripital/ pattern
linear
Friction
Contact
area
Static
Drag
Kinetic
Units


Algebra/geometry/pre-calc
speed/accelerations
angles + trig
language
syntax/word-order
+
definition
real-world details
(friction etc..)
vectors/velocities
forces
real-world experiments
& calculation
motion


limits


Kinetic
Potential
gravity
electricity
Field
Force
tension
Push
Normal
Contact
Friction
Fluid
inertia
Rotation
Change
Interations
Acceleration
Field strength
Position
velocity
Relative acceleration
Relative velocity
Relative Position
Collision



Position v time
= Velocity
Vectors
Component Vectors
Vector Math
Displacement Vector
graphs
$\frac{\Delta v}{\Delta t}$ = acceleration
$\vec{a} = \frac{v^2}{r}$
Uniform Circular Motion
Forces
$\sum \vec{F}_{net} = m\vec{a}$
$\vec{F}_g, \vec{F}_t, \vec{F}_n, \vec{F}_f$
FBP
$\vec{F}_n$
$\vec{F}_f$
$\vec{F}_T$
$F_g$ (9.8 m/s²)
Magnitude of $\vec{F}$

# (CONCEPT MAP)

Unit conversions & scientific notation

Velocity - instantaneous vs. average → $\bar{v} = \frac{\Delta x}{\Delta t}$ $v = \frac{dx}{dt}$

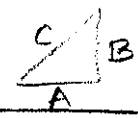
acceleration - instantaneous vs. average → $\bar{a} = \frac{\Delta v}{\Delta t}$ $a = \frac{dv}{dt}$

$\Sigma F = ma$ ↔ Vectors - <u>direction</u> with acceleration

Free Body Diagrams

(Forces) - GRAVITY (9.8 m/s²) - NORMAL - TENSION - FRICTION -

- $W = mg$
- N = Newton = measurement of a force
- magnitude = $C = \sqrt{A^2 + B^2}$




(where $A = F\cos\theta$ & $B = F\sin\theta$)

circular acceleration

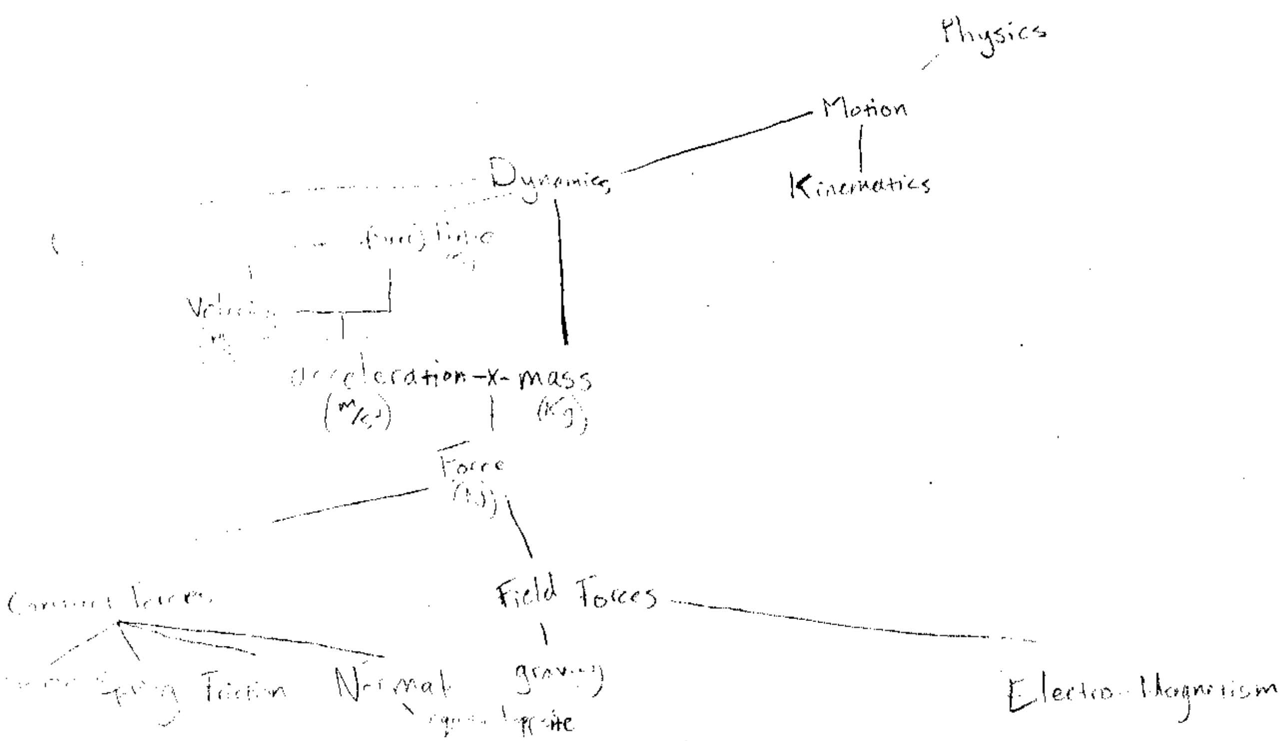
$a = \frac{v^2}{r}$

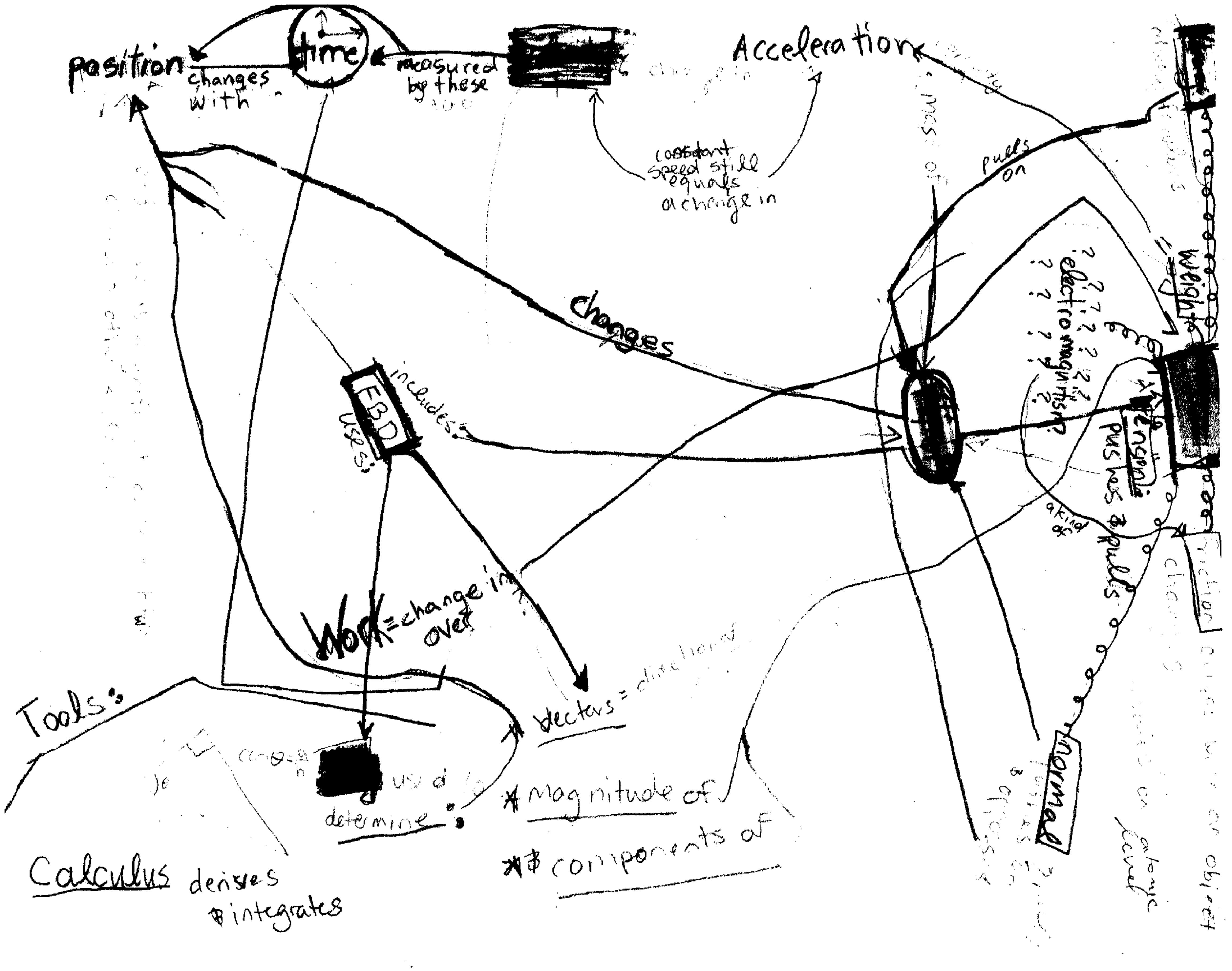
TRIG.

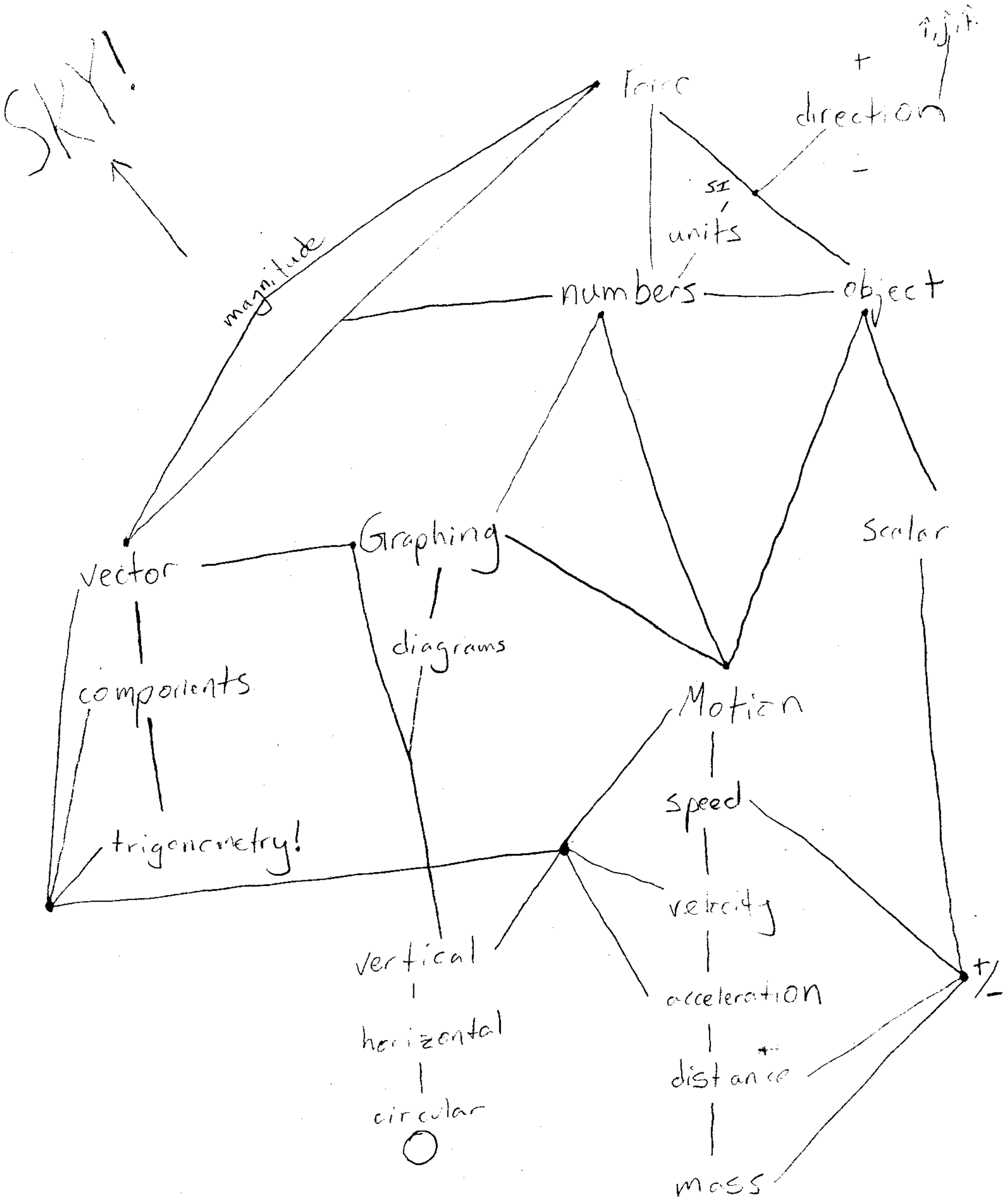
$\sin = \frac{opp}{hyp}$

$\cos = \frac{adj}{hyp}$

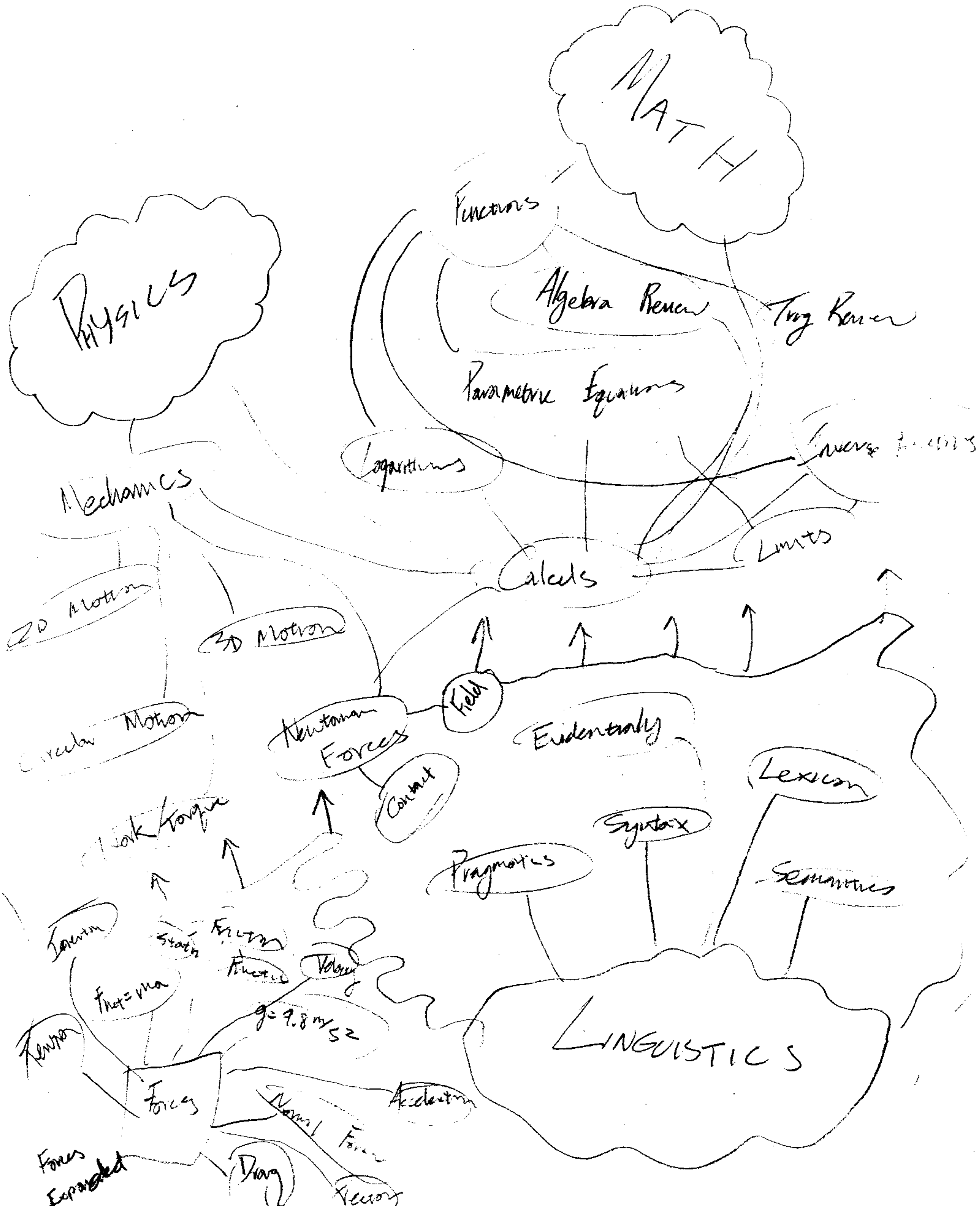
$\tan = \frac{opp}{adj}$

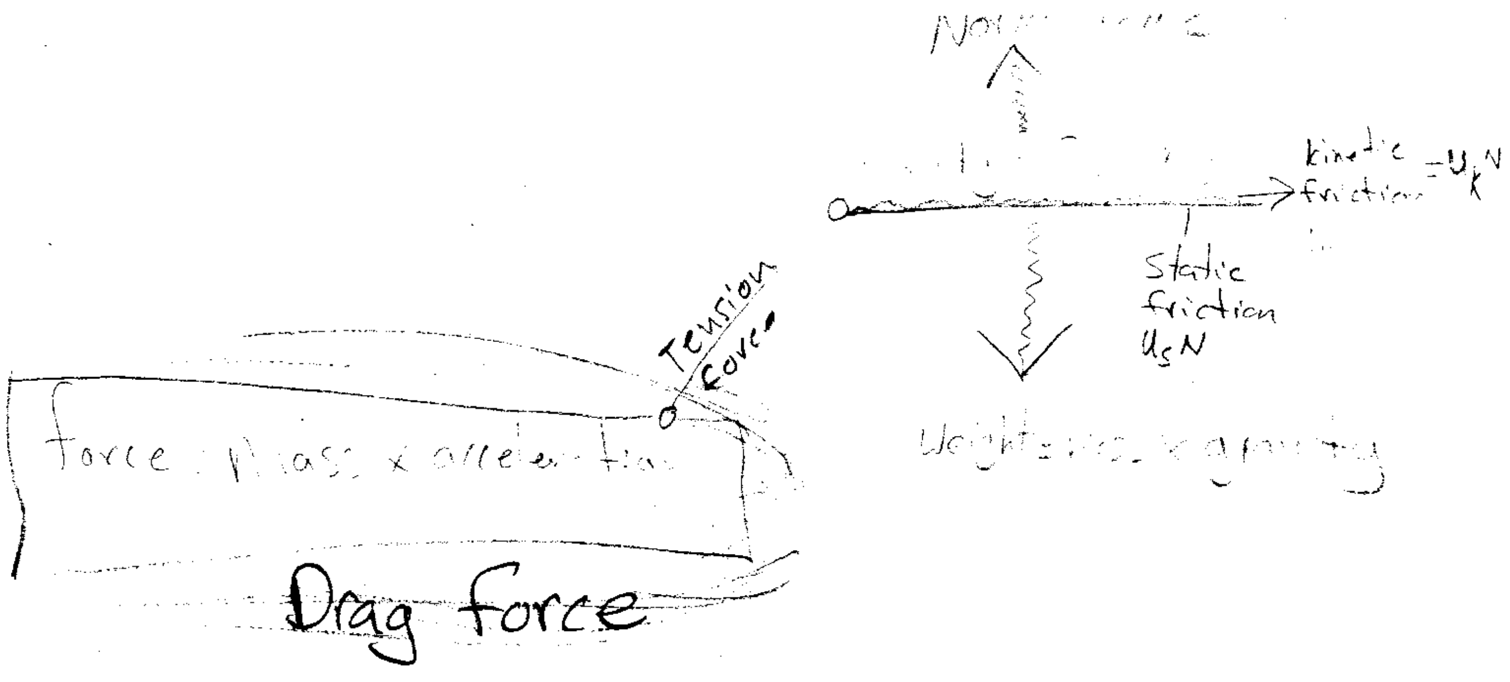

Physics
Motion
Kinematics
Dynamics
Velocity
acceleration -x- mass
(m/s²)
(kg)
Force
Field Forces
Contact Forces
Spring
Friction
Normal
gravity
Electro-Magnetism


position
changes with
time
measured by these
Acceleration
constant speed still equals a change in
pulls on
weight
electro magnitism?
tension
pushes & pulls
a kind of
friction
normal
changes
FBD
includes
uses
Work = change in over
vectors =
* magnitude of
*& components of
used determine
Tools:
Calculus derises & integrates



SKY!
Force
+
direction
-
SI
units
magnitude
numbers
object
Graphing
vector
Scalar
diagrams
components
Motion
speed
trigonometry!
velocity
vertical
acceleration
+/-
horizontal
distance
circular
mass

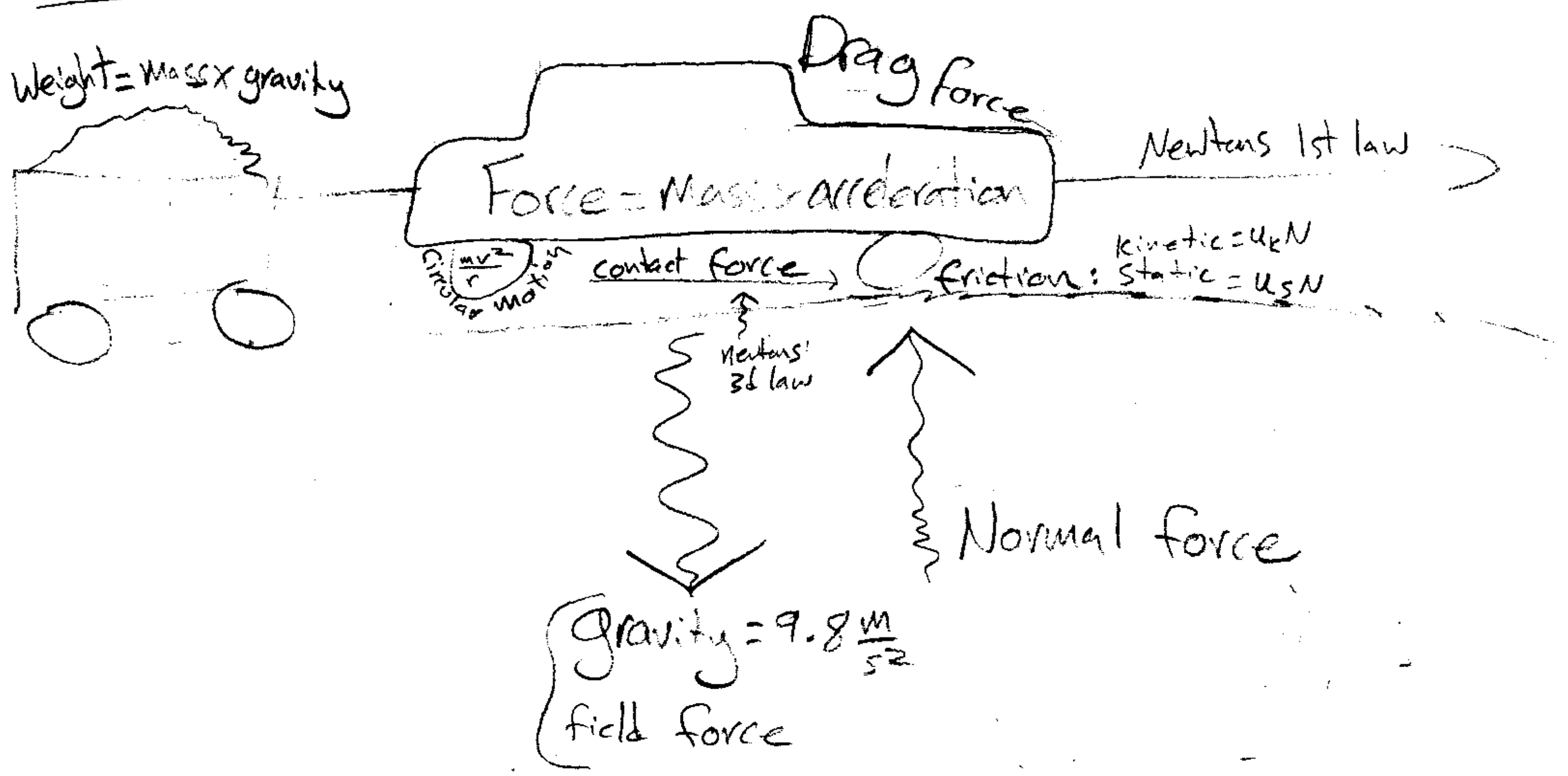

MATH
Functions
Algebra Review
Trig Review
Parametric Equations
Logarithms
Calculus
Limits
PHYSICS
Mechanics
2D Motion
3D Motion
Circular Motion
Work
Torque
Newtonian Forces
Field
Contact
Evidentiality
Lexicon
Syntax
Pragmatics
Semantics
LINGUISTICS
Tension
Static
Friction
Kinetic
Velocity
$F_{net}=ma$
$g=9.8\ m/s^2$
Newton
Forces
Normal Force
Acceleration
Drag
Vectors
Forces Expanded

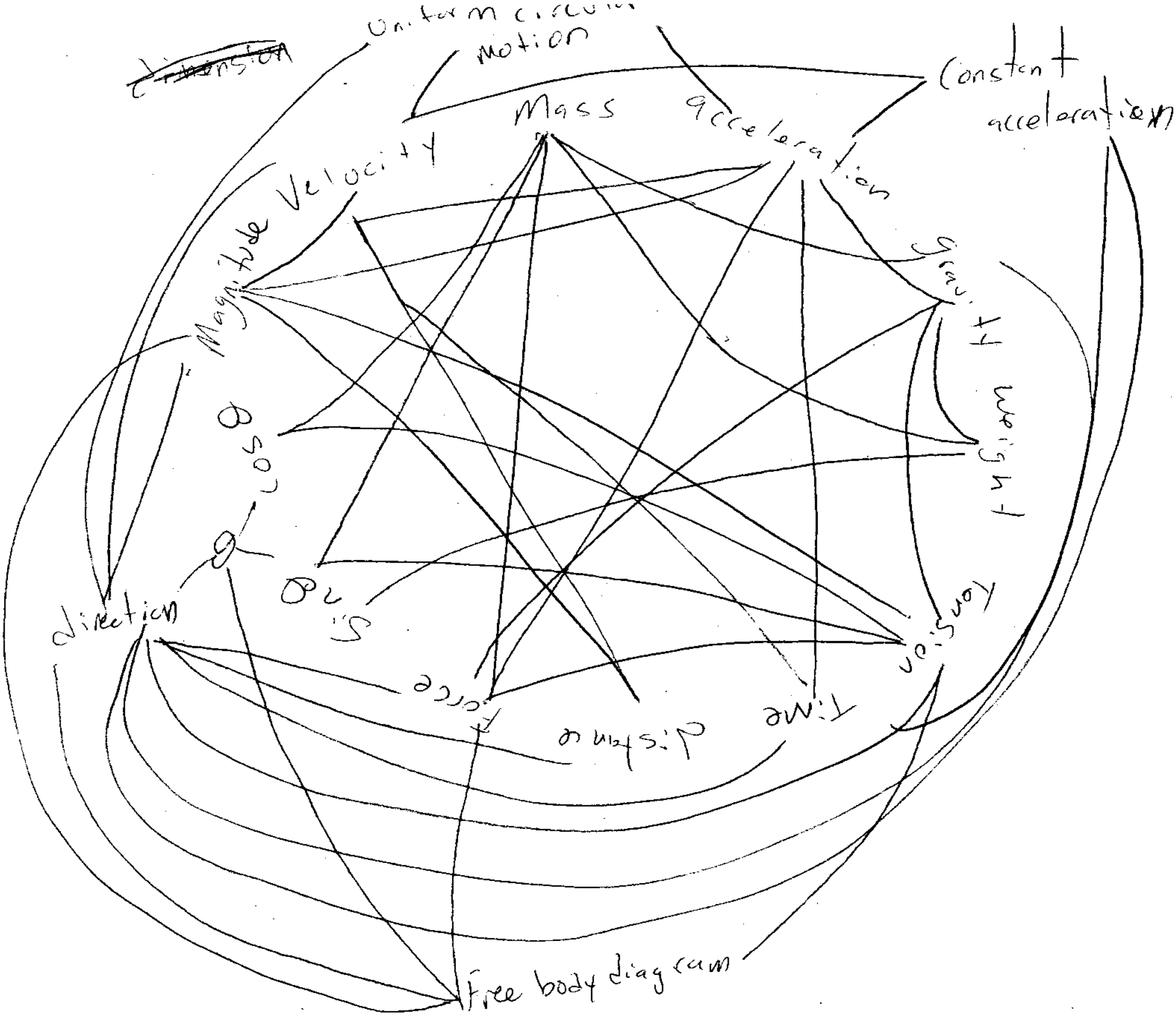




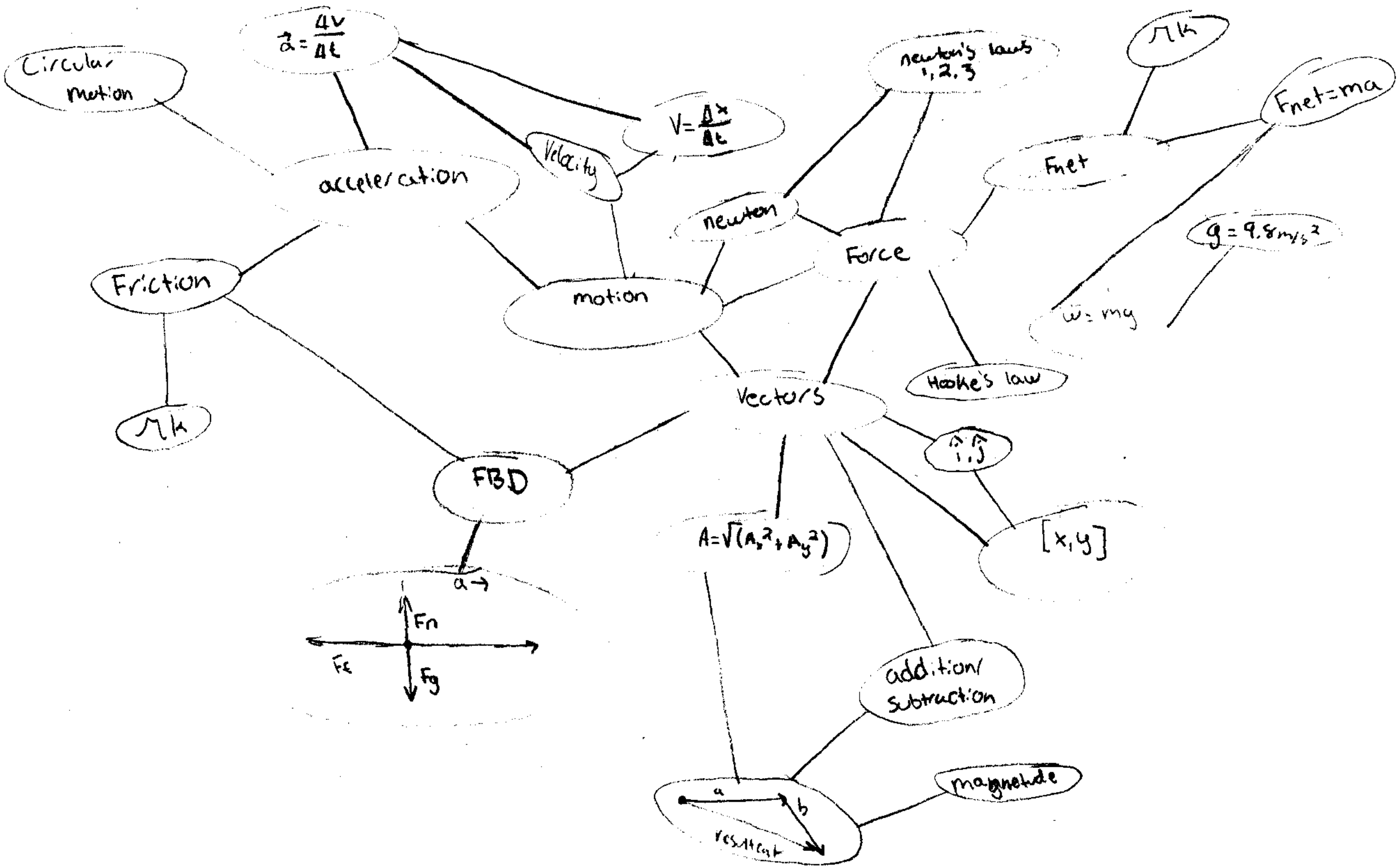
$\underline{\text{velocity}} = \frac{\Delta X}{\Delta T} \rightarrow \text{acceleration} = \frac{\Delta V}{\Delta T}$

Inertia

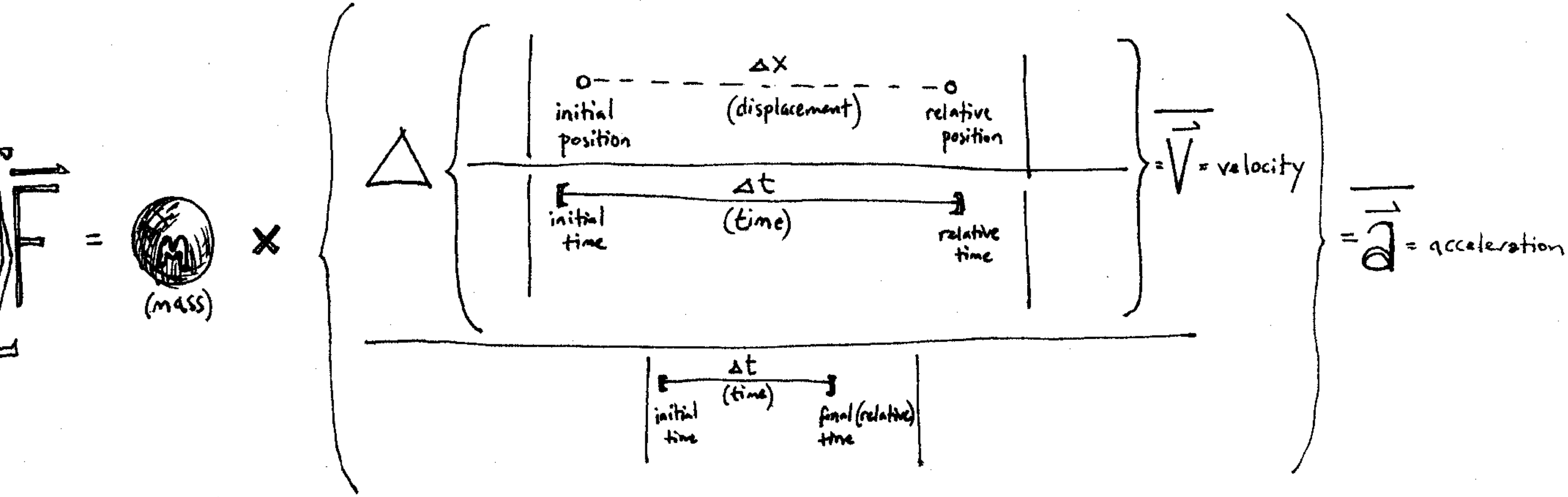




~~Dimension~~
Uniform circular motion
Constant acceleration
Mass
acceleration
Magnitude
Velocity
gravity
Weight
cos θ
θ
sin θ
direction
force
distance
Time
tension
Free body diagram


Circular motion
$\vec{a} = \frac{\Delta v}{\Delta t}$
acceleration
Velocity
$V = \frac{\Delta x}{\Delta t}$
Friction
$\mu k$
motion
newton
newton's laws 1, 2, 3
Force
Fnet
$\mu k$
Fnet=ma
$g = 9.8 m/s^2$
w = mg
Hooke's law
Vectors
$\hat{i}, \hat{j}$
[x, y]
FBD
a →
Fn
Fg
Ff
$A = \sqrt{(A_x^2 + A_y^2)}$
addition/subtraction
a
b
resultant
magnitude

# Concepts in Force & Motion




N (newtons) = kg (kilogram) × m (meters) ÷ $s^2$ (seconds per seconds)

**NEWTON'S LAWS**

1. FORCE CAUSES CHANGE IN MOTION
2. rate of change in momentum = $\Sigma \vec{F} = m\vec{a}$
3. FORCES ALWAYS OCCUR IN PAIRS

Terms

$\bar{V} = \frac{\Delta \text{displacement}}{\Delta \text{time}}$

$\bar{a} = \frac{\Delta \text{velocity}}{\Delta \text{time}}$

Vectors $= \sqrt{x^2+y^2}, \theta$

Unit vectors $= \vec{A} = \hat{i} + \hat{j}$

$\vec{V} = \frac{\Delta r}{\Delta t}$

$\vec{a} = \frac{\Delta V}{\Delta t}$

Uniform Circ $= a = \frac{v^2}{r}$

$\vec{F}_{net} = \frac{d\vec{p}}{dt}$

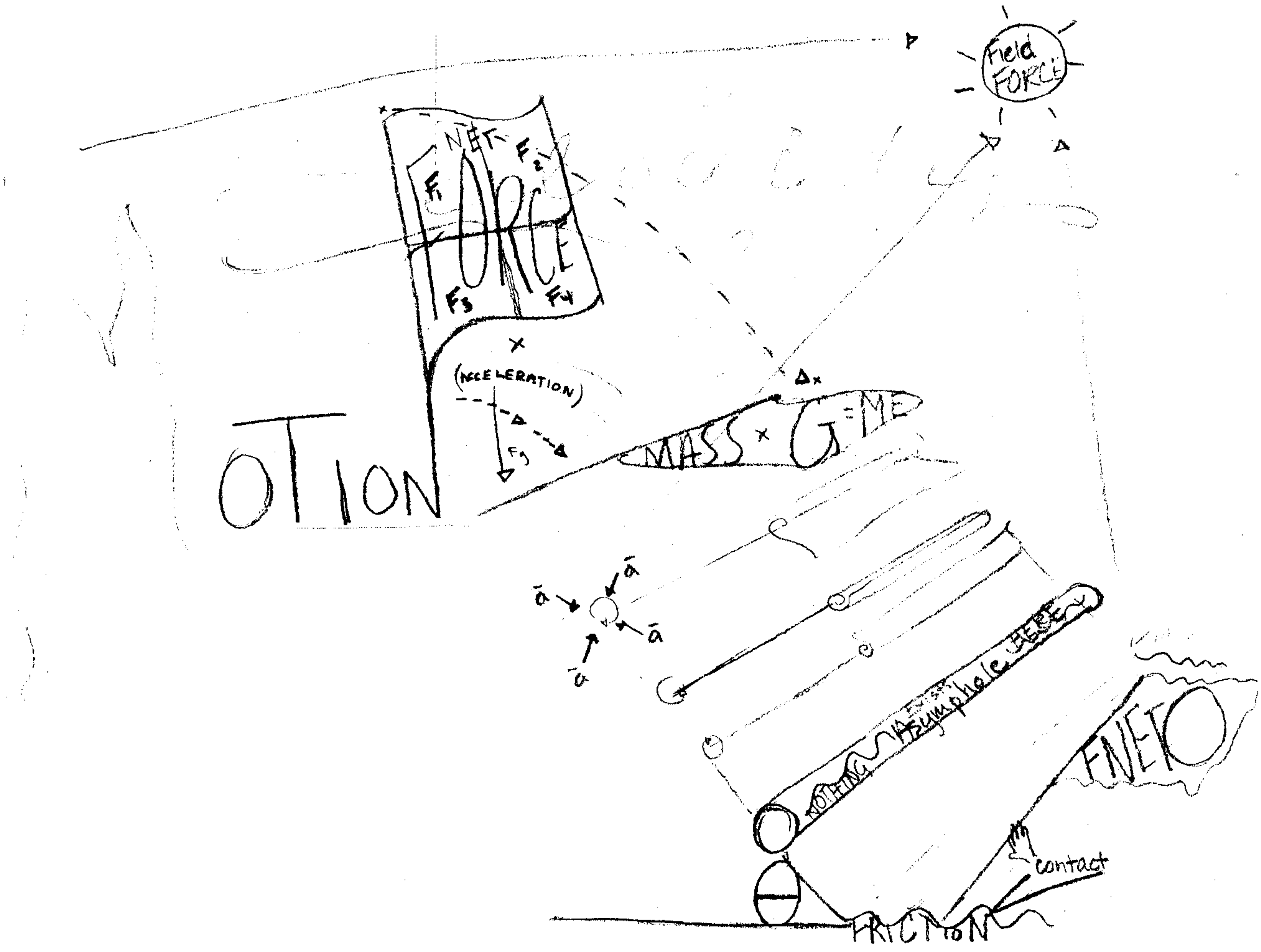
$\vec{F}_{net} = m\vec{a}$ (Constant mass)

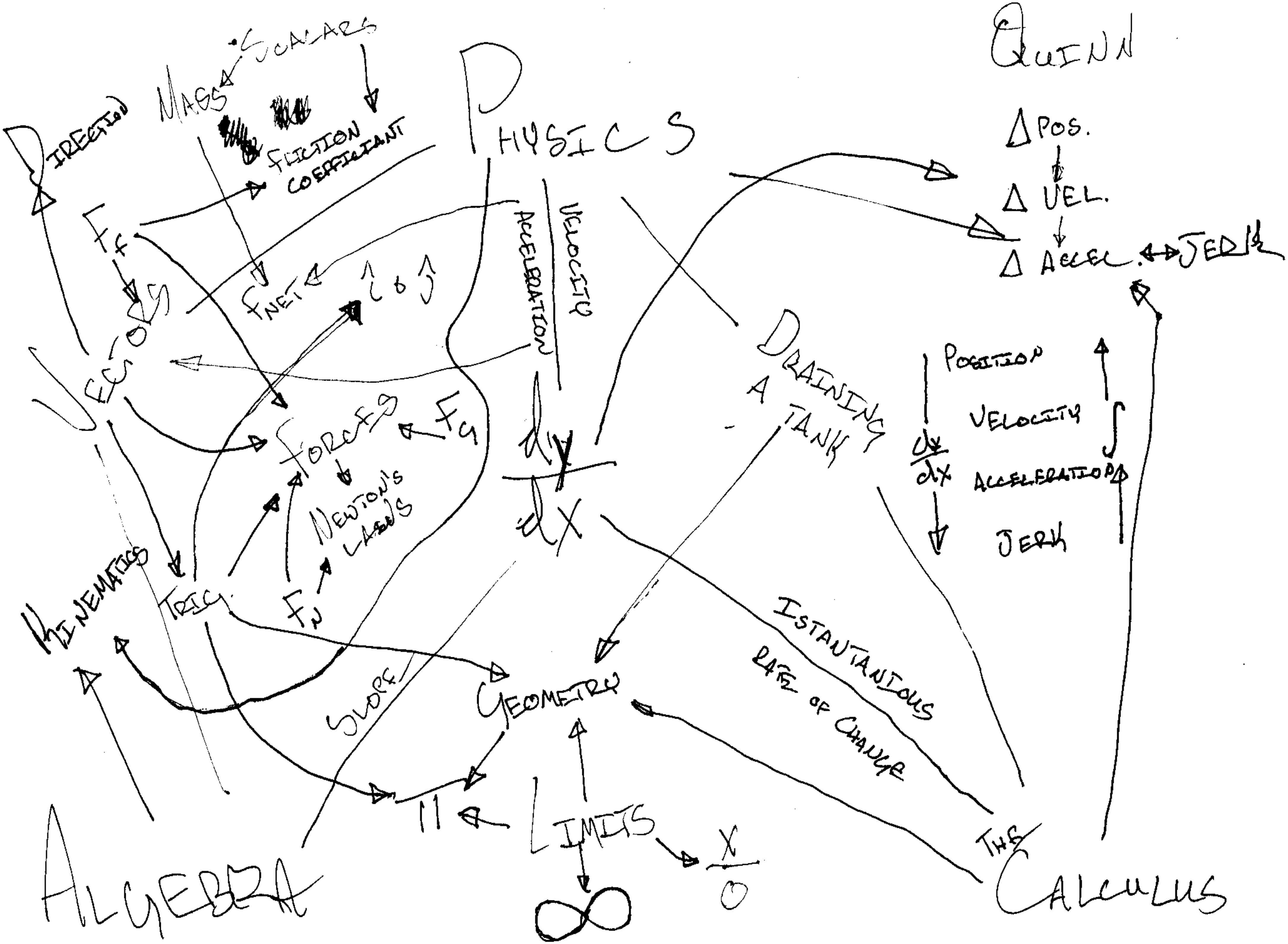
$N_{3rd}$ law

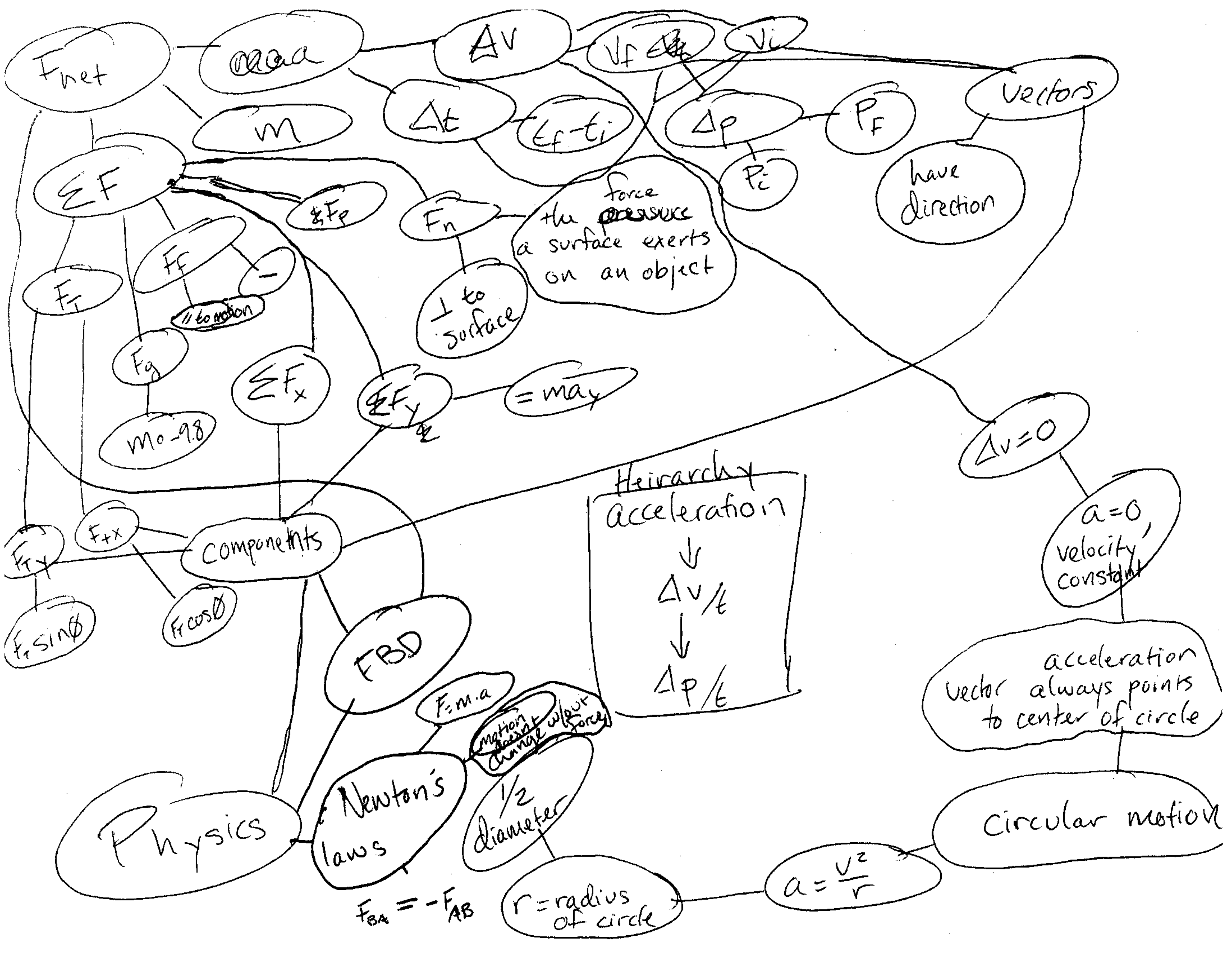
Friction $= f_s$ or $F_K$

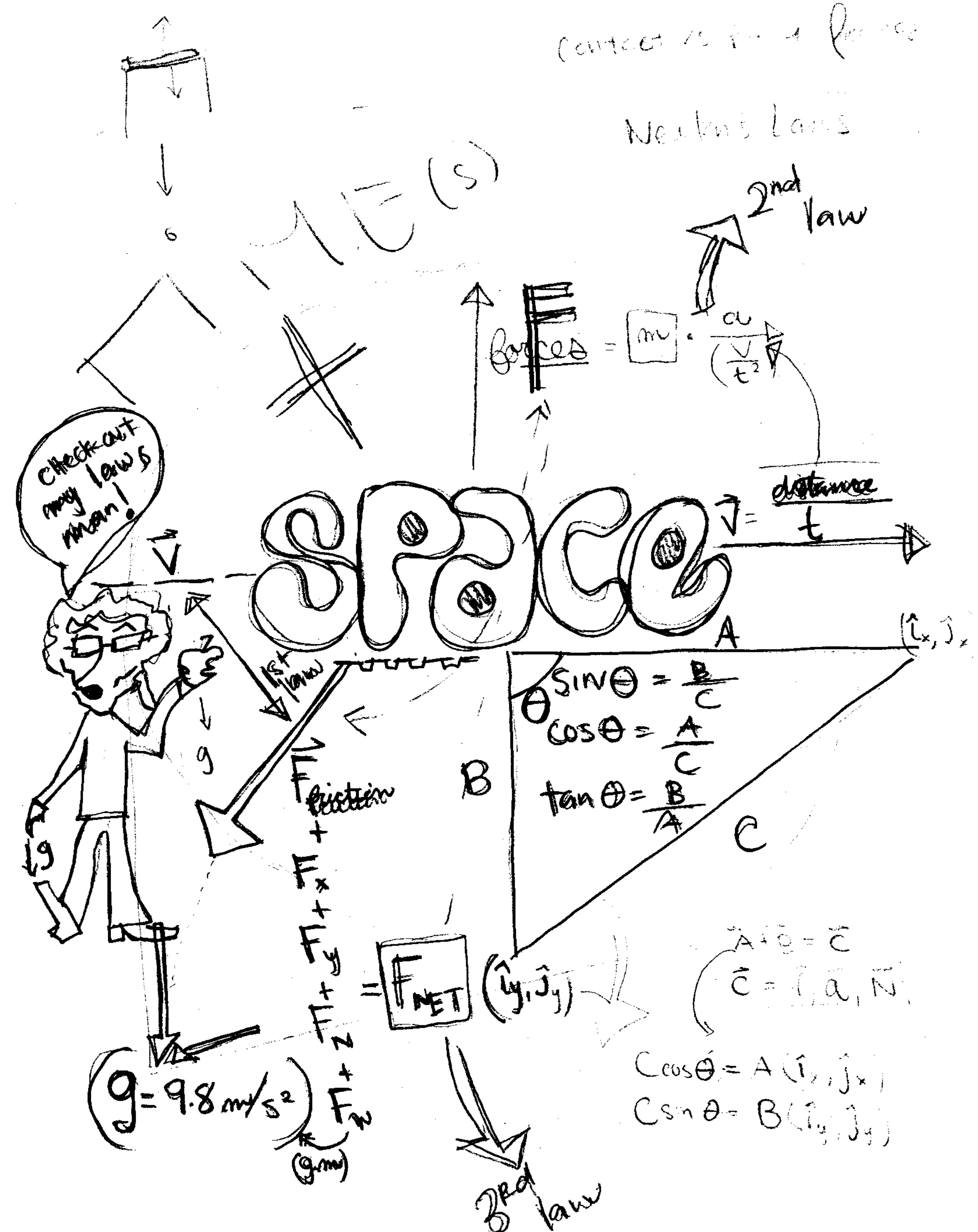
# Concept Map

Vectors + $\vec{V}$ \$ $\bar{a}$ + Newtons Laws = (Physics For Me Currently)

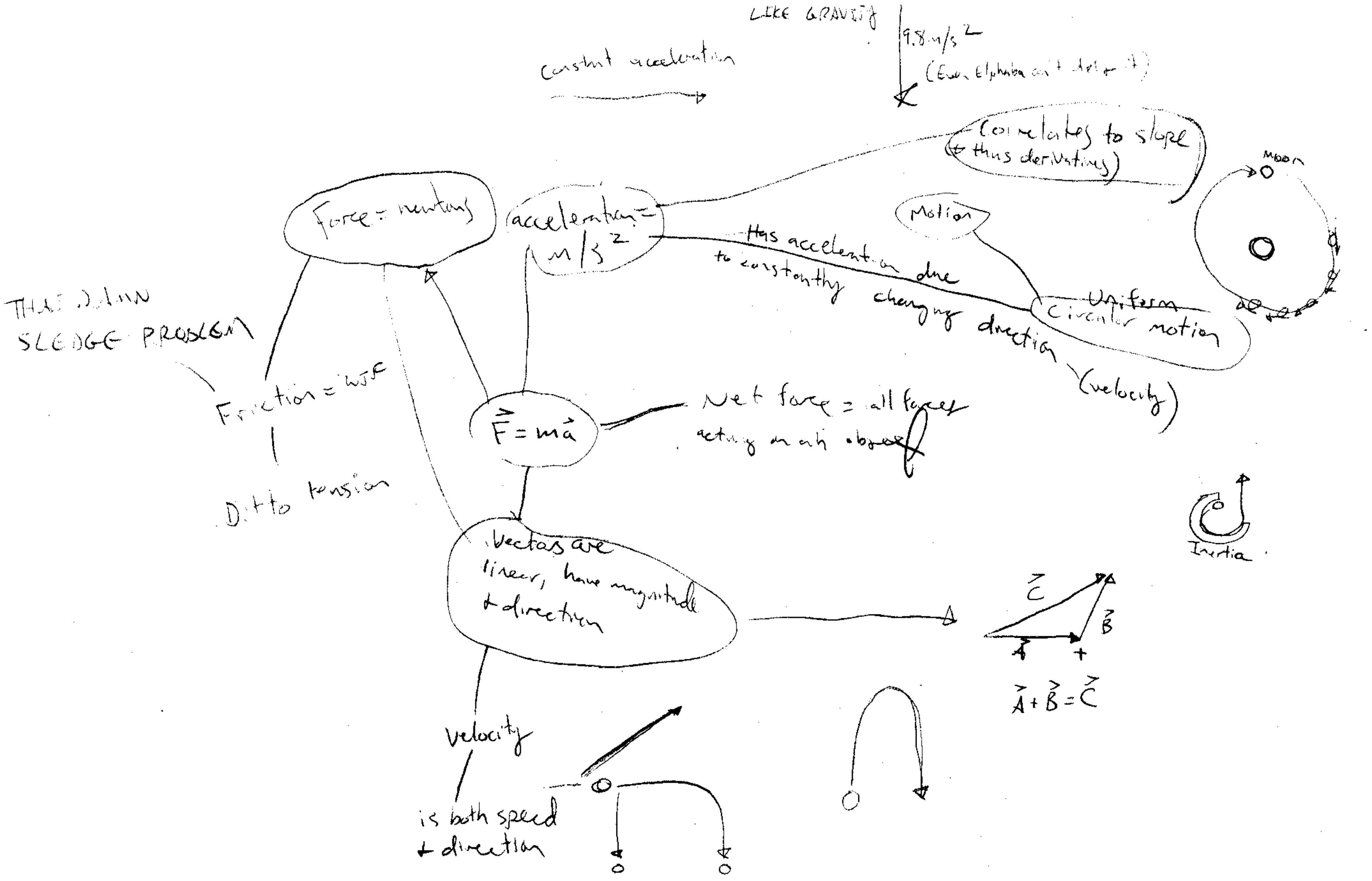

Field FORCE
NET FORCE
$F_1$
$F_2$
$F_3$
$F_4$
(ACCELERATION)
$F_g$
OTION
$\Delta x$
MASS × G = ME
$\bar{a}$
NOTHING Asymphole HERE
FNETO
contact
FRICTION


Quinn
Physics
Mass
Scalars
Direction
Fliction coefficiant
$F_f$
$F_{net}$
Vectors
Forces
Newton's Laws
$F_g$
$F_N$
Trig
Kinematics
Velocity
Acceleration
$dy/dx$
Draining a tank
Δ pos.
Δ vel.
Δ accel.
Jerk
Position
Velocity
Acceleration
Jerk
$\frac{dy}{dx}$
∫
Istantanious rate of change
Geometry
Slope
Limits
∞
$\frac{x}{0}$
Algebra
The Calculus


Fnet
ma
m
Δv
Vf
Vi
Δt
tf-ti
Δp
PF
Pi
Vectors
have direction
ΣF
ΣFp
Fn
the force a surface exerts on an object
⊥ to surface
FT
Ff
−
‖ to motion
Fg
m·9.8
ΣFx
ΣFy
=may
Δv=0
a=0, velocity constant
Heirarchy
acceleration
Δv/t
Δp/t
FTy
FTx
Components
FT sinθ
FT cosθ
FBD
F=m.a
motion doesn't change w/out force
1/2 diameter
acceleration vector always points to center of circle
Physics
Newton's laws
circular motion
FBA = −FAB
r=radius of circle
a = v²/r

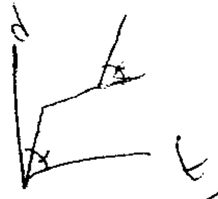


Newtons Laws
2nd law
forces = m · a (V/t²)
check out my laws man!
SPACE
V = distance / t
1st law
sin θ = B/C
cos θ = A/C
tan θ = B/A
A
B
C
F friction + F x + F y + F N + F w = F NET
g = 9.8 m/s²
(g·m)
3rd law
A + B = C
C cos θ = A (î x, ĵ x)
C sin θ = B (î y, ĵ y)



LIKE GRAVITY
9.8 m/s²
(Even Elphaba can't defy it)
constant acceleration
Force = newtons
acceleration = m/s²
(correlates to slope (+ thus derivatives)
moon
Motion
Has acceleration due to constantly changing direction (velocity)
Uniform circular motion
THAT DAMN SLEDGE PROBLEM
Friction = WJF
Ditto tension
F⃗ = ma⃗
Net force = all forces acting on an object
Inertia
Vectors are linear, have magnitude + direction
C⃗
B⃗
A⃗
+
A⃗ + B⃗ = C⃗
Velocity
is both speed + direction

# ←Forces→

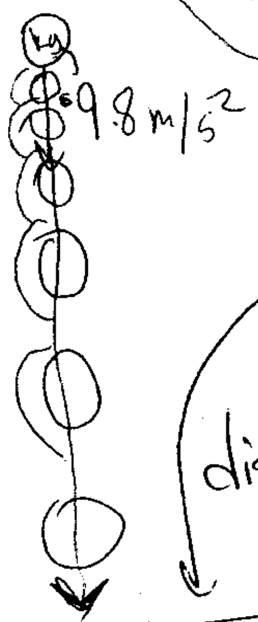



$\bar{v} = \frac{\Delta d}{\Delta t}$: motion in a straight line (one dimension)

average velocity explains rate of change in motion
instantaneous velocity consists of isolating a point by using two intervals on a graph as they approach eachother. slope at a


$\bar{a} = \frac{\Delta v}{\Delta t}$: I explain acceleration as the rate of change in velocity, or the "rate of change of the rate of change in position w/ respect to time

Gravity: earth's gravitational pull on an object. includes the mass of object. 9.8m/s². (mass in units)

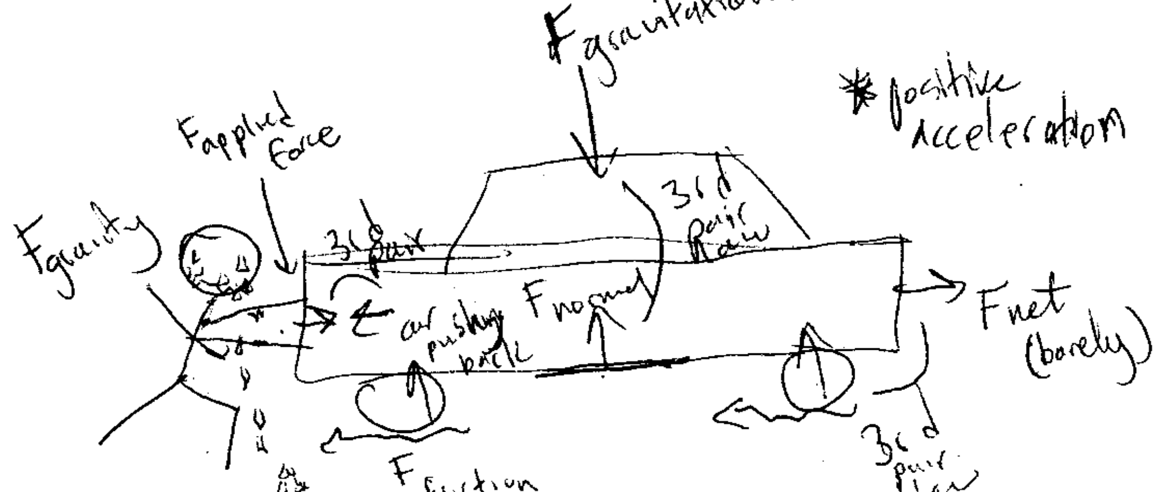


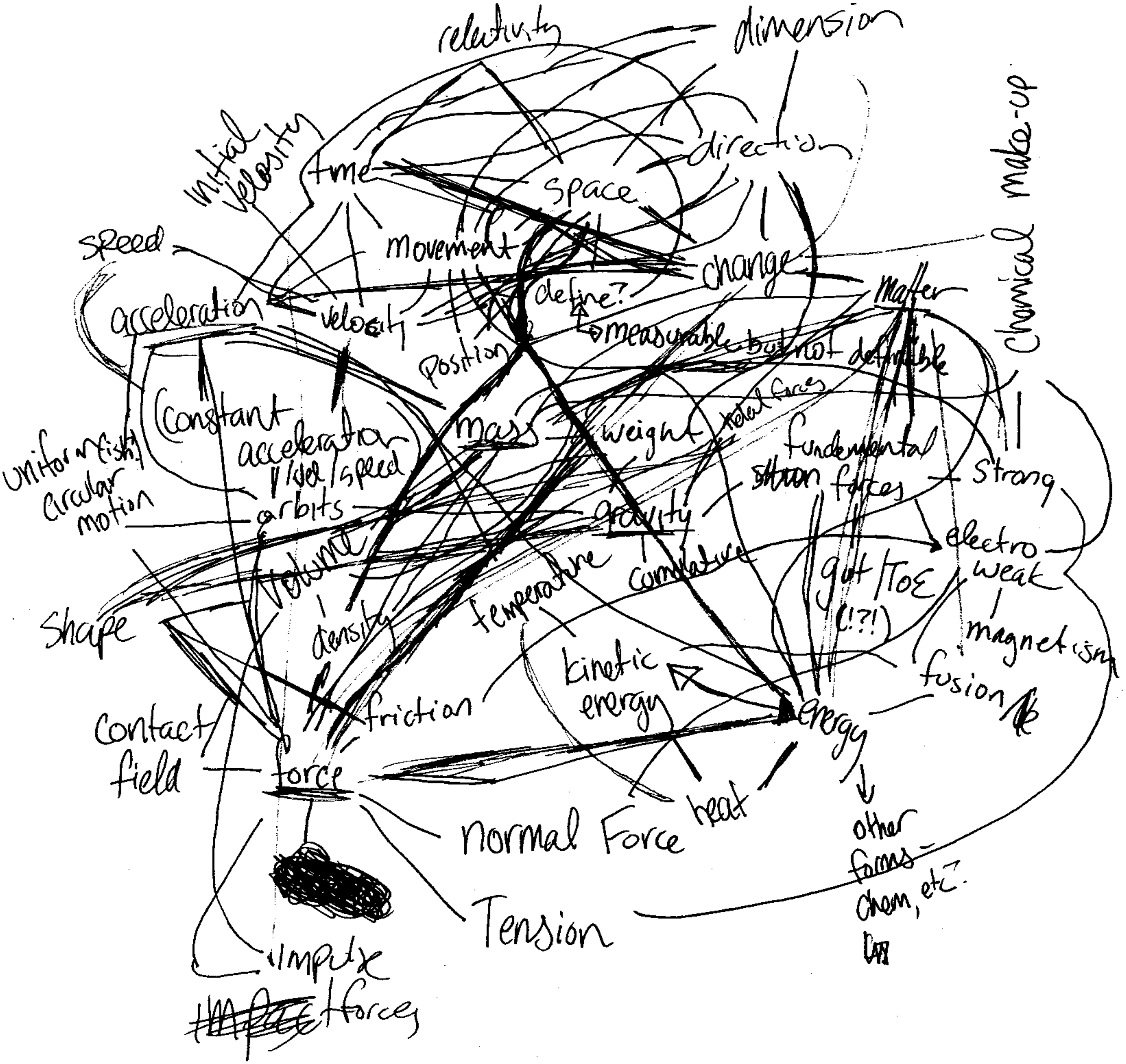

each interval increases due to constant a

Vectors → components
Vectors → displacement → acceleration
components → Fnet
acceleration → Newton's Laws
Fnet → Newton's Laws
Vectors → forces

forces: applied, static

Newton's Laws




relativity
dimension
initial velocity
time
space
direction
chemical make-up
speed
movement
change
matter
acceleration
velocity
define?
measurable but not definable
position
constant acceleration
vel/speed
mass
weight
total forces
fundamental forces
strong
uniform(ish) circular motion
orbits
gravity
electro weak
volume
cumulative
temperature
GUT/TOE
(!?!)
magnetism
shape
density
kinetic energy
fusion
contact
field
friction
energy
force
heat
other forms
chem, etc?
Normal Force
Tension
impulse
forces