**Forward:**

1. After Sputnik, there was an influx in youngsters wanting to build rockets, for the first year it seemed almost every single one of them was inspired and pushed to pursue space exploration
2. Safety manuals were released to help students experiment safely, but accidents happened, even fatal ones.
3. People tried to ban it saying it is unsafe, and that amateurs will never discover something the professionals couldn’t
   1. Things are unsafe, but accidents happen due to carelessness and uneducated attempts
   2. A medical student dissects a hand for a final exam at a top medical school… could tell him that he would not learn anything that could not be found in texts. He is doing it physically as some thing must be learned by physically doing something, lifting out blood vessels and muscles to find something new for others
   3. If the first generation of rocket scientists began as amateurs, what do they expect the next generation of rocket engineers to do? Learn to draw parts without any knowledge on what they do, where they fit, and why they exist?

**Chapter 1**

1. Why do you want to experiment with rockets?
   1. It shouldn’t be for the fire… that is looking for a hobby. It should be about the power of the industry, what it can do for humanity as a steppingstone.
2. What do you hope to achieve by it?
   1. It shouldn’t be to get entertained, etc. It is about gaining the knowledge and experience to expand your work into more powerful rockets capable of more to humanity.
3. Are you willing to make the sacrifices and take the elaborate precautions necessary?
   1. If not, then go somewhere else, cause this shit can hurt and kill people.
4. The major aspects of amateur rocketry
   1. Organization
   2. Safety
   3. Scientific Method
5. Organization
   1. This is a group effort, not just for one or two people.
   2. Most productive comes from smaller (5-15) people that are WELL organized.
   3. A group needs financial backing... things can be expensive and to do what you want you need to be able to purchase the appropriate hardware.
   4. Groups can fill up with ‘too many cooks’ that can weigh down a group… bottom third, must be handled well
      1. Avoid people with the tendency to always argue about things that are small, or someone who is always unhappy with how things are run and reject all cultural change from the current leadership.
   5. Consists of ‘7-8 bright young men’ lol sexist, it was the 60’s from a military officer
   6. Wide range of the basic sciences… i.e. many majors and years with a large network of knowledge
   7. Should have a common pursuit to expand their knowledge in the subject with the contribution of their experience.
      1. Mechanical, electrical, pure science, radio etc
   8. As a group grows, there should be leads in each particular side of the rocket project to lead the people under, helps disperse knowledge and pull from the rest of the team in experience and time
   9. A technical advisor is important, tag-up with professors and other experts constantly to check in on designs
   10. The importance of a constitution
       1. Keeps everyone with a good understanding of how the organization is run
       2. Helps with future intense conversations on leadership changes
       3. Aligns the mission of the club and transfers to each members of the club
   11. Any notes on the constitution he attached into his book?
   12. Safety code? UNH SEDS should make a safety code with the election of the next safety advisors
   13. Sponsorship is very important to any agency, allows you to buy the equipment needed
   14. Rocket make news, and rocket enthusiasts hit the papers easily.
   15. Nearly every person is impressed by young people who show initiative and the enterprise that is not expected of them… an impressive rocket program is a sweet spot of becoming huge and important and known quick
   16. Must show a community what you are capable of, and the publicity to come from that will bring waves over the next year, allowing the next accomplishment.
       1. We haven’t had a big win yet that caused this… but its coming
   17. Make friends with the reporters in the area… they need to be pulled and told about the progression of the club so they want to stay involved and writing when something bigger comes up
   18. People can be impressed when students talk about a subject that is over their head, makes them want to contribute as they want to be a part of greatness and enabling future leaders in something that sparks everyone mind when young.
       1. FOLLOW-UP IMMEDIETLY
   19. Get to know the city officials, they will help you make moves for things that require city or official attention such as high impact tests
   20. People aren’t interested in supporting a fireworks team, but they WILL be interested if your work is leading to something greater then yourself, or just that year. Not a fad
   21. Don’t bother people for technical advice with a whim. Schedule formal recurrent meeting to ask about flushed out ideas/problems. Need to maintain a good relationship to continue to use their support
   22. A somewhat simple idea can turn into a pipe dream just a week later of thought.. happens all the time
6. Safety
   1. We weren’t at the moon when this book was written…
   2. You don’t want to lose an appendage… safety critical
   3. Must be a primary thing that every member practices and thinks about constantly
   4. A rocket propellant can be an explosive real quick…
   5. Not really a difference between a rocket and a bomb… the only difference is that there is a hole
   6. A rocket flies fast enough to kill
   7. Most accidents happen when people are doing something they did a thousand times and became to used to the action that they skip steps and draw blanks and don’t notice
   8. Establish a by the number procedure, follow checklists when you can when you are doing something over and over
   9. Personal and group safety practices
      1. Safety rules are for you
      2. Research before building… its experimental, do your due diligence
      3. Never work alone
      4. Don’t hide activities
      5. get an adult supervisor
      6. safety lies in orderliness and neatness
      7. be prepped for emergencies
      8. listen to advice always
      9. organize work before starting
      10. consider the safety of others
      11. prepare for the worst, always
7. Safety thru scientific procedure
   1. Adopting a scientific procedure to your projects also helps with safety… makes it more intelligent collectively
   2. Plan a good working procedure that makes sense for your project
      1. Research
      2. Experimental design
      3. Preliminary design
      4. Building your full-scale mockup
      5. Test models and working scale models
      6. Final design
      7. Prototype construction
   3. Doing the above proves that you have developed a rocket, not just built one.
   4. Once you get to hotfire test and launches, must see the law. Work with the city.
   5. There are rules now for launching, but hotfires are really with your city and communicating with them
   6. Never take a chance with the law

**Chapter 2 – Basic Rocket Design**

1. The rocket motor, although very modern looking, is the oldest motor known to man
   1. Seven centuries
2. It been in the 30s and 40s that man started to put it to practical use
   1. The tech and materials needed to actually put it to use only came in the last 7 decades, which is why it began to be developed for more practical use as we evolved as human
3. Great discoveries are often not utilized until long after the discovery (centuries) as it needs other technologies to be developed for the proper use of the discovery useful to humans
   1. The steam engine took 200 years to be used from the mind of newton when Welsh though to use the new steam beams as the rail that tit could ride on
   2. Needed cylinder and pistons to be made to handle the internal pressure of the engine too!
4. Rocket prop is on newtons third law
   1. Every action there is an equal and opposite reaction produced.
   2. If you lift someone that weight 200 lbs one foot above the ground, you are exerting 200 foot lbs on the earth. Earth should move, but is so heavy it isn’t measurable
   3. Firing a gun
   4. Throwing something heavy on an ice rink
5. Rocket engine, hot gases are produced by means of rapidly burning some chemical substance called a propellant
   1. No two props will burn efficiently by itself, but together they produce a lot of hot gases used for newtons third law
6. The gases produce a pressure inside the chamber that is used as the driving force of forcing the gases out of the engine in the direction that is wanted
7. Part of an engine
   1. Injector (if liquid)
   2. Combustion chamber
   3. Nozzle (escape port)
8. Other main parts of a rocket are:
   1. The nose cone
   2. The fins
9. Achieves forward motion by expelling the gases in one direction to accelerate the rocket in the other direction
   1. Must not burn so fast to cause an explosion but enough to have a stable combustion for acceleration
   2. The hot gases don’t physically hit anything, it is just their apparent velocity and their mass that cause the change in momentum following newtons laws
10. Talk about page 43
11. The chamber cannot over pressurize
    1. A matter of engineering design of the engine
    2. Burning temperature
    3. Burning rate
    4. Size of chamber
    5. Composition and thickness of chamber wall
    6. Diameter of throat
    7. Length of nozzle
12. Solids can burn unevenly if not prepped right
    1. Causes variation in thrust and nozzle output direction, bad flight trajectory
13. It is advisable that amateur rockets:
    1. Be overbuilt to FOS
    2. Be tested with ultimate safety achieved
14. They are free flight rockets, meaning it can go in any direction and should be assume it will go horizontal immediately
15. Rule of thumb nozzle designs, diameter to diameter, common for solids and especially ones that burn very quickly
    1. Attach them with machine screws with oring
    2. Can thread! Just got to be careful for preop prep etc
    3. Nozzle must be aligned with the center line of the rocket to ensure straight flight
    4. Must be a strong, corrosion resistant material
16. The rocket body must be strong and temp resistant!
    1. Bulkhead is for solid, injector acts as the top of a rocket engine that uses a oxidizer liquid
    2. Can be brazed instead of using oring
17. Nose cone balances the rocket and cuts into the flow path of the rocket
    1. Different designs can be used to better traverse the atmospheric air
    2. Should be tight into the rocket, no wobble!
    3. CG must be forward of the CP, forward of fin surface for sure, CP can now be calculated
18. Fins give stability to a rocket when you need to move the CP back more to get behind CG. More aero surface that adds pressure vectors on the under side of the rocket
    1. Three is common, gives all modes of movement
    2. Aluminum is common, machine screws
    3. Design can be made perfect now with computes lol
    4. Always good to go larger then cut fins smaller
19. Diaphragm and igniter
    1. Diaphragm is like a burst cap, hold pressure to support ignition and startup to get fast initial speed
    2. Should be fired from a distance away
20. Much more is learned from failure then success. Foster that feeling to pursue success, we all need it sometime to verify we are going in the right direction
    1. Causes of failure can usually be determined by a good test procedure and analysis after. Cherish that experience and LEARN from it

**Chapter 3 – Rocket Propellants**

1. Fuel is propellant
   1. There is a fuel (reducer)
   2. And an oxidizer
   3. Both must be present to support desired combustion
2. Old school fuel ox is JPL-4 (high kero) and fuming nitric acid
3. Liquids and solids
   1. Lol to saying that these are just the beginning, will invent better methods for getting off earth
4. Some auto combust, some need help
5. Mono prop is one liquid that pumps into the chamber and combusts with the help of ignition
   1. Minimizes the amount of plumbing and tanks
6. Single base and double base for solid
   1. Just has to deal with chemistry composition, not too important
7. **Liquids**
   1. Liquid has an oxidizing agent, and a fuel from the hydrocarbon family
      1. Easily oxidizble for combustion
   2. The specific impulse details the ability of a prop combination to produce thrust and it is expressed in seconds
      1. The higher, the more efficient the fuel is to produce thrust
      2. Specific thrust sometimes is used for liquids to also factor in the amount of propellant getting pumped into the chamber
   3. Dangerous
   4. Expensive compared to solids
   5. Advantages
      1. High energy yield
      2. Available chemicals
      3. Combustion temp lower and less combustion pressure, helping with weight of motor
      4. Fuel flow can be controlled
      5. Not really affected from changes in temp pressure humidity
   6. Disadvantages
      1. Elaborate plumbing
      2. Dangerous
      3. Toxic
      4. Moving is hard, and fueling can be tricky
      5. Low density creates a bulk displacement
   7. Combustion performance
      1. Fed into motor under pressure
      2. Nitrogen and/or a solid pump used to increase pressure from storage tanks to motor
      3. Will learn more in the motor systems chapter
      4. Mono prop is the same methods
      5. Ignition timing very important!
      6. Entered into the chamber in helical pattern to help cool as well before combusting all of it
      7. Shock waves are very important, must design dampers to deal with this
      8. When temp and pressure builds, thrust is strong enough to lift the system
      9. How much thrust produced is tons of factors
         1. Injector, chamber, propellant, nozzle design
      10. Goal to accelerate the particles as fast as possible out of the nozzle
      11. The higher the temp in chamber, and lower molec weight (gaseous) the faster the particles will be moving
      12. Not possible in 60’s to model what will actually happen
          1. Possible now to do this, but stil cant model completely what actually will happen
          2. Especially shock waves and best way to dampen
      13. The molec weight of the exhaust products is what is important
          1. Relationship lies with flame temp, molec weight and specific impulse exists
      14. Specific impulse with more fundamental constant is on page 62
      15. Another way is from measuring average exhaust velocity and normalizing to gravity
      16. Thrust is produced from the chamber to the nozzle exit, NOT AT THE NOZZLE EXIT
      17. Goal is to allow the gas to dissipate as fast as possible to atmospheric pressure
          1. Would create a back pressure if it doesn’t do this fast that would slow the rocket down
      18. it’s the difference of zero speed in chamber to a high speed which creates thrust. The change is what matters!!!
      19. Impulse is the measurement of the speed with which a given velocity is reached
      20. No such things as a safe oxidizer, all are bad for humans
      21. Some oxidizers boil at very low temps, they need to be kept at near vacuum and a relatively low temp to keep it from boiling off. That’s why rocket vent to maintain most liquid and continuously vent off the liquid to gas products to fill with more liquid
      22. A bunch of info on certain oxidizers used
   8. **Solids**
      1. Lower ratings of specific impulse but easier and better well kept, etc.
      2. Don’t experiment here.. use what is known and only if you have the facilities to do it
      3. **Advantages**
         1. Low toxic
         2. High density which saves space and weight in rocket airframe
         3. Ease of handling
         4. Lower cost
         5. Easier to ignite cause one spark can set it off, technically
      4. **Disadvantages**
         1. Lower performance
         2. Can decompose over time
            1. Liquids don’t really if stored well
         3. Cracking can occur when making, which can cause burst of combustion, hard to predict and design for
      5. **Danger and Hazards**
         1. Can blow up in your face
         2. Powder form solids can be violent… must be aware and carefully handle
         3. Some combust spontaneously when exposed to air…. Never use that shit
      6. **Propellant grain shapes and methods of forming**
         1. Cast or molded same size of combustion chamber
         2. Molded into or onto an insert that then gets put into the chamber
      7. Restrict burning on certain sections of grains
      8. **Burning rate**
         1. Chamber pressure affects the burn rate
         2. Determined empirically from tests after test
         3. Burns perpendicular to the surface
         4. Many different grain types, each with a different thrust curve that will be produced
         5. Inch per second
         6. The larger the burning surface, the faster the burning rate will be
            1. because more heat and larger pressures produced
         7. Burning time is simple, linear inch / second compared to how many total linear inches it has
      9. Always take what has done before as rule of thumb, but when safe, experiment for yourself if you want to learn more in depth on why
      10. Classic propellant is potassium nitrate and sugar!
      11. Zinc and sulfur are also used and can produce rocket that go up high enough for basically any rocketeer
      12. Density of packing can greatly change the burning rate of a powder grain
      13. Purity, particle size, density, amount of air present, conductivity of the chamber walls
      14. He used zinc and sulfur as a guide to prepare a mixture for an engine, with all the calculation, etc
      15. Talks about loading propellant into the chamber for casting
      16. Funnel, any end, mold
      17. Igniter should be inserted on the stand as solid are easy to ignite
      18. **Safety**
          1. Read this, but a lot of it is common sense!

**Chapter 4 – Rocket Motor Systems**

1. Principals of Propulsion
   1. Rule of thumb calculation argument… good sometimes but bad practice in advanced topics for sure
   2. Propulsive force is from the rapid expansion of the gases which is produced with the propellant burning
   3. More efficient in space is there is no push back, it actually makes it worst to a rocket engine and performance of a rocket
   4. Every action there is an equal and opposite reaction
   5. The 1atm is hitting the propellant pressure, back pressure slowing it down
   6. Referred to as ambient pressure
   7. Objective of a good motor design
      1. Burn for maximum amount of gases and highest pressure
      2. Enable them to flow out opposite of desired direction of motion and with least obstruction
   8. The speed of which a gas get to max velocity is what is important
   9. Nozzle converging and diverging sections
      1. De Laval, as tube decreases, gets faster, and reached min diameter at the throat
      2. Increase speed as they reach the sonic velocity
      3. Hose analogy
      4. Diverging gives opportunity for the gas to expand rapidly and get to atmospheric pressure so no back pressure is created
      5. It gains speed from this diverging because it is expanding a the same time, and designed right gets to max speed at the end of the nozzle
      6. Be built of the right material to handle stress and heat and corrosion
      7. Maximize kinetic energy must be obtained
      8. Allow gases to expand and reach atmosphere at the end of the nozzle
2. Rocket Design for Amateurs
   1. Pressure is a function of flame temp and burning rate of propellant which is a result of the burning surface getting burnt
   2. Burning surface is from the design of the grain and the chamber
   3. **Figure on 106 is good to talk about**
   4. Rule of thumb for nozzle dimensions of around 1/3 nozzle throat D to ID
   5. 30 degrees converging and 15 degree diverging
   6. Cross sectional area of nozzle exit should be 7-8 times bigger then the nozzle throat
   7. With rule of thumb, nozzle exit wll always be slightly smaller then the combustion chamber ID
3. **More Advanced Rocket Trust Chamber Calcs**
   1. Determined from the propellant used
   2. You get a k, ratio of specific heats, and R, the gas constant.
   3. Hard to calc, got to take the research word for it from tables!
   4. At the throat, the velocity is M=1 when designed correctly
   5. Will expand and increase to super sonic after the throat during gas expansion rapid
   6. Goes thru all the equations on nozzle stuff pages 111-118
4. **Features of Liquid Motor Systems**
   1. Drawing page 123
   2. Regen cooling to cool walls rapidly, helps with mass and also increases temp of propellant to support combustion
   3. Different thrust control features for mag and direction with gimbal, aux jets, deflectors
5. Other systems
   1. Nuclear power
   2. Ion
   3. Direct particle accelerator

**More Advanced Rocket Design**

1. The purpose of a rocket defines the process of design
   1. Types of design specifications
2. Exhaust velocity determines how fast the rocket can get!