



SunChase 2022 Technical Overview

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SUNCHASE



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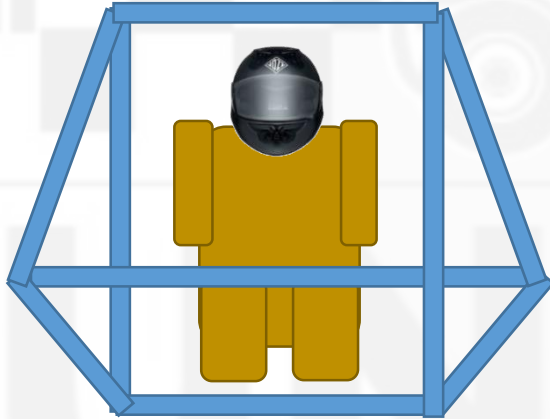


Frame & Roll Cage

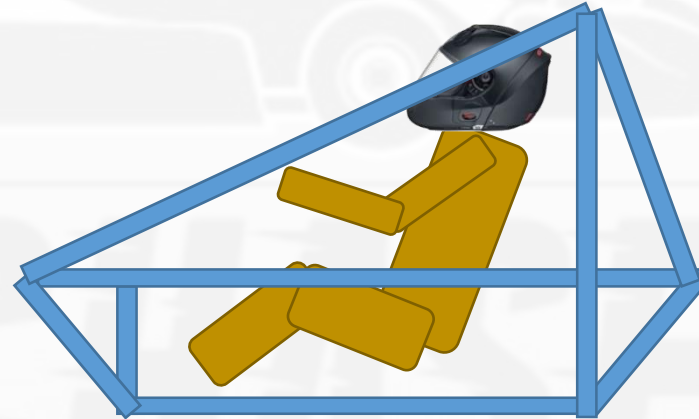
- Protects the Driver in the event of an accident.
- Must:
 - Surround the driver: it can't protect them if they aren't inside it).
 - Be structurally sound: if the roll cage fails, the cage itself can injure or trap the driver.
 - Not present a hazard to other drivers, or obstruct the drivers ability to safely operate the vehicle.

Quality Check

- Size:
 - There should be a clear space between the driver (in a normal seated position) and the frame and/or roll cage, when observing the driver from **any** angle.



Front OK



Side NOT ACCEPTABLE



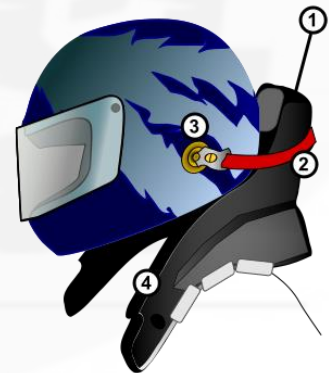
Quality Check

- Strength
 - Determining the required strength of the frame and roll cage is much more complicated, and is a function of total vehicle weight (including loads like the driver), and maximum reasonable velocity.
 - Most go-kart frames are safe up to 30mph, but you should check the specs on your frame.
 - If you are modifying or building your own frame, be sure to consider material (be specific, there are LOTS of different steels/aluminums/alloys, each has different strength properties), as well as size and thickness.
- **Rule of Thumb:** The frame should be able to support the entire weight of the kart and driver at **any** point.
 - If you are not comfortable lifting the entire kart or resting it on any point of the frame, it is not strong enough.



Safety Harness & Helmet

- Keeps the driver inside the vehicle and distributes the force of impact evenly across the driver's body.
- 5-point harness is very efficient at both of these tasks, but needed to be attached and adjusted properly.
- A full helmet helps protect the head & restricts the motion of the neck to help prevent injury.
- Head and Neck Support (HANS) are a more robust version.





Rolling Resistance

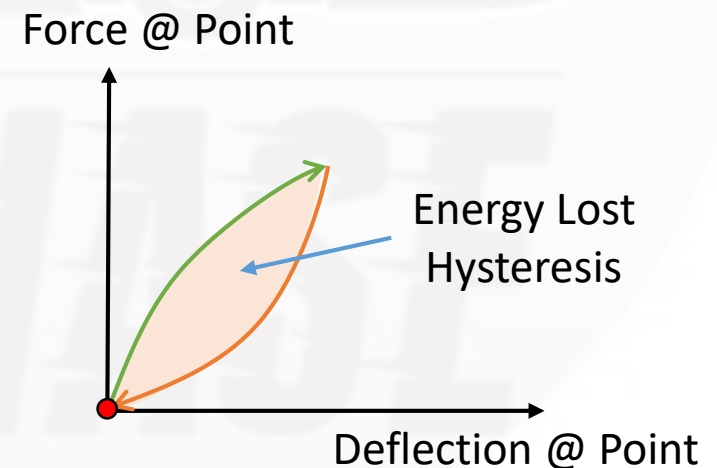
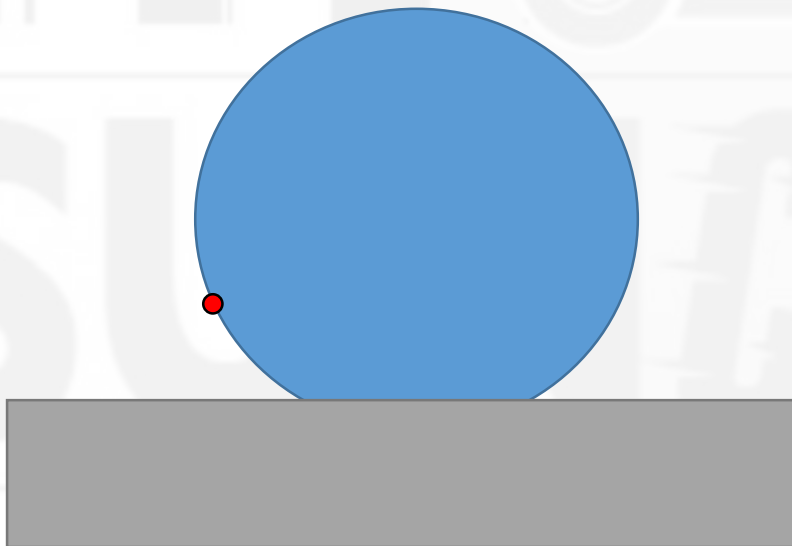
- 1 of your 2 major losses of energy!
- Rolling resistance (RR) is a function of the coefficient of rolling resistance (C_{rr}) and the weight of the vehicle (N)

$$RR = C_{rr} * N$$

- It is often easier to significantly reduce C_{rr} than it is to significantly reduce N (although it is best to control both).

Rolling Resistance (continued)

- Primary component of losses due to rolling resistance are associated with hysteresis of the force-deflection curve of the wheel when in contact with the ground.



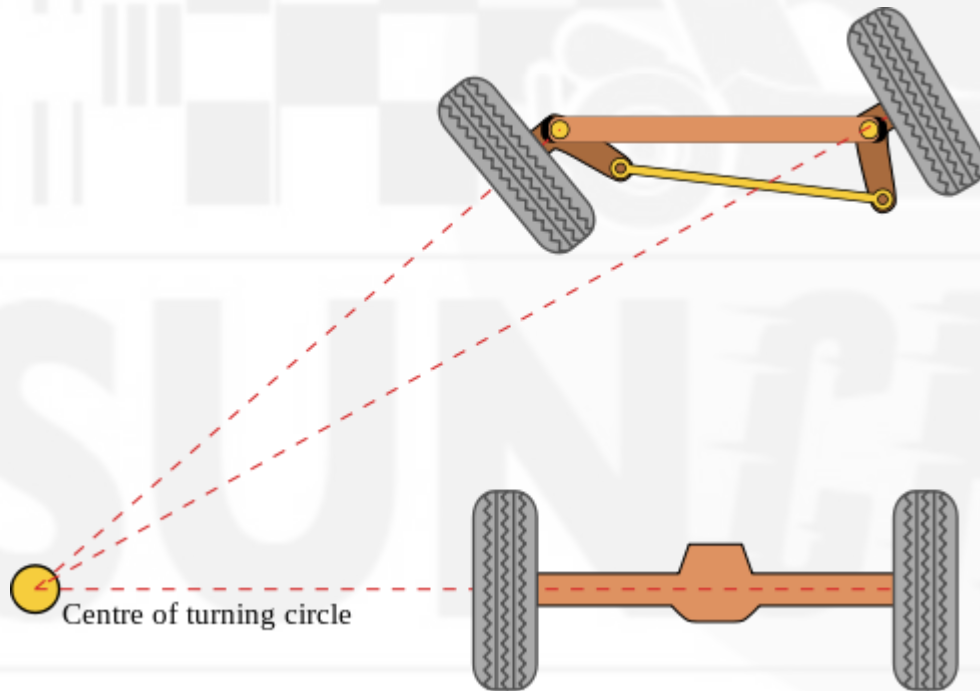


Limiting Rolling Resistance

- Limit the deflection of the tire (stiffer tires), get tires that have limited viscosity (harder to determine).
- For pneumatic (air pressure) tires, higher pressure generally results in lower rolling resistance (if the tire is rated to support the pressure).
 - Over-inflating tires can have a negative effect (causes the tire to bulge in the center resulting in more total loss).
- This is pretty easy to test, use a fish scale (or luggage scale) to measure how much force it takes to move your kart (disconnect the drive train first).
 - You can also easily observe how significant this can be by riding your bike a short distance with $\frac{1}{2}$ pressure in the tires, then fully inflating them and trying again.

Steering & Rear Differentials

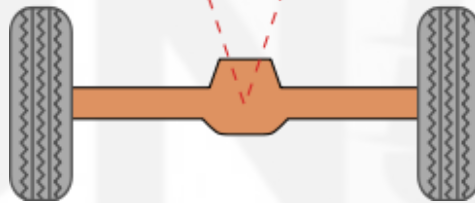
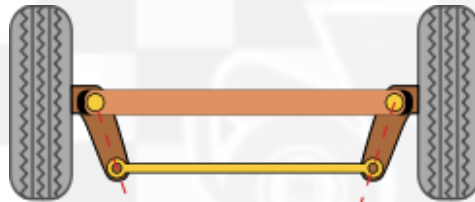
- Not all wheels turn at the same rate or at the same angle when the car is turning.



- The radius (distance) from the wheel on the inside of the turn is less than that on the outside.
- This means the inner wheel needs to steer more, and has a lower velocity than the outer.

Steering & Rear Differentials

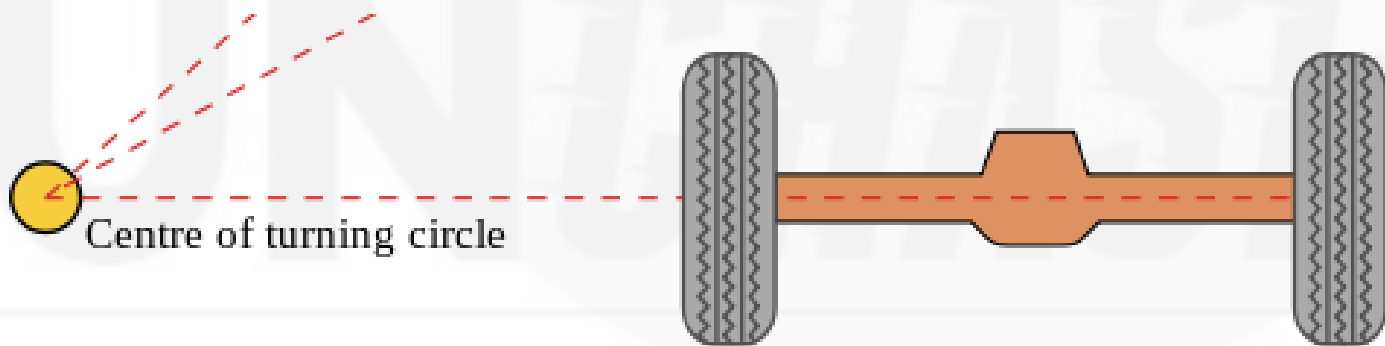
- Proper steering (Ackermann) geometry can account for the difference in steering angle.





Steering & Rear Differentials

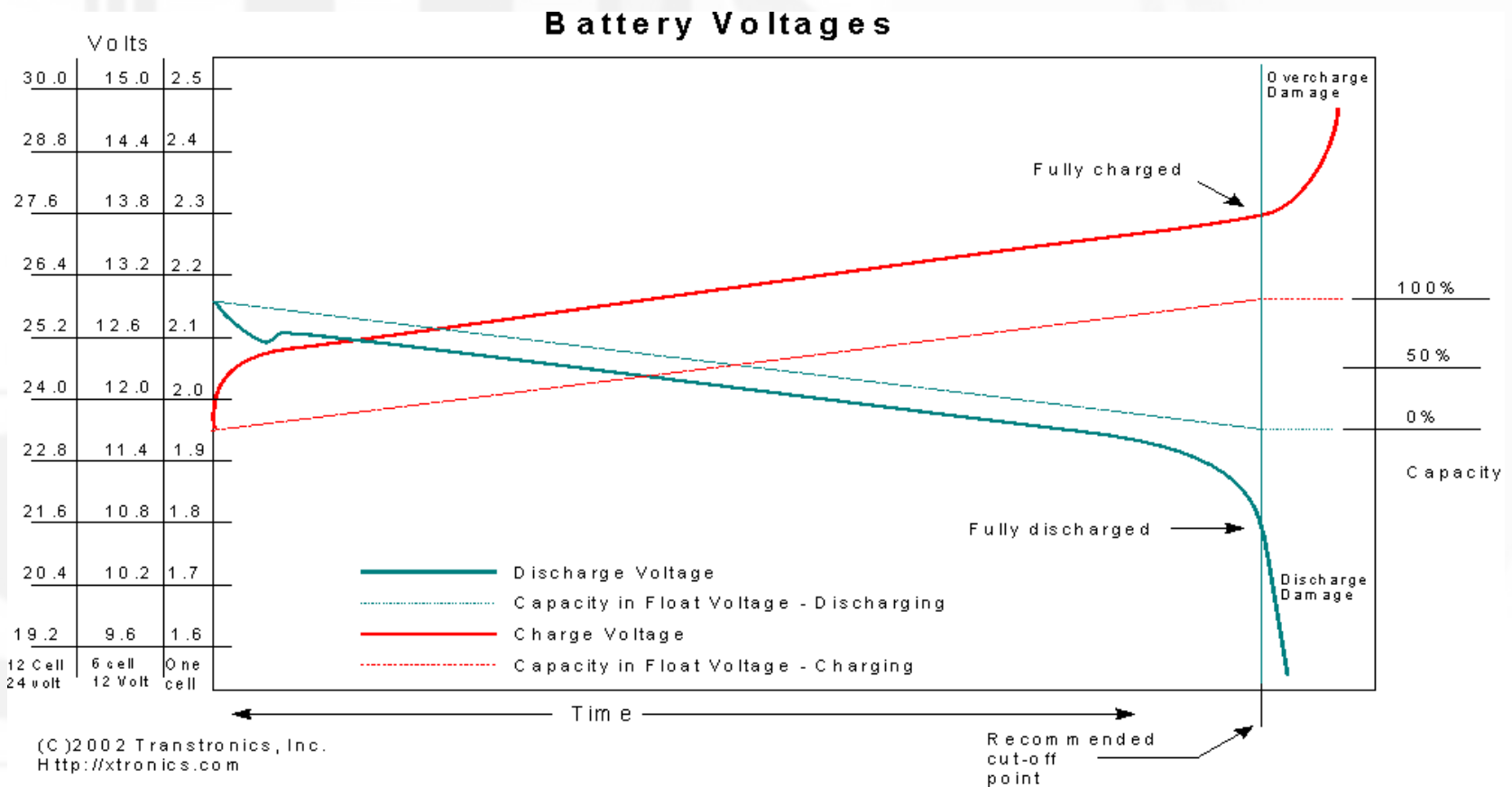
- The velocity at all points of a body is equal to the distance to the center of rotation (R_p) times the angular velocity of the body (w)
- The center of each wheel has a different R_p .
- A differential allows 2 wheels on the same axle to turn at different speeds.



Battery Capacity

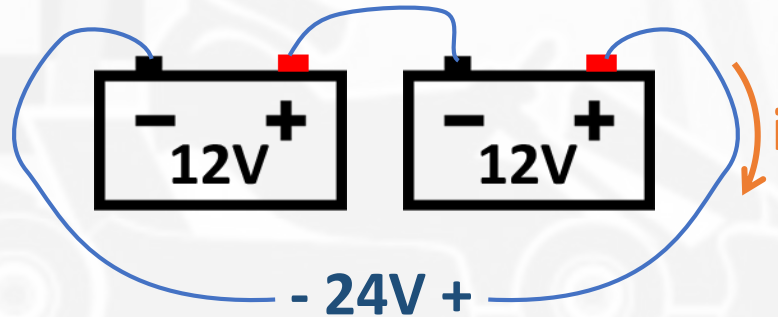


- Charge / Discharge curve for lead-acid battery (note just an example, each battery is different).

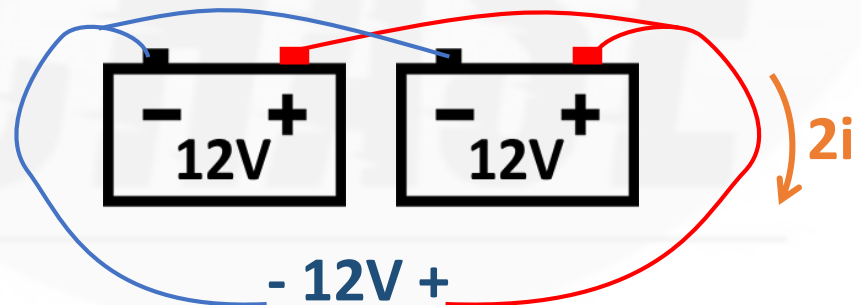


Electrical Systems

- Voltage adds in series, but pulls the same current from both batteries. This can lead to an un-even drain of power.



- Current adds in parallel, but requires that batteries have the same voltage. This helps keep charges of each battery equal (assuming the same type).



- Same principles applies to the PV panels as well



Controllers

- Charge controllers & motor controllers help control the voltage and flow of current to maximize the efficiency of the batteries and the panels.
- They do this by controlling either voltage or current to keep each unit operating at it's nominal (idea) range (usually tuned for peak efficiency).

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Motors & Power

- It is important to understand the power & efficiency curve for your motor. This will help you determine:
 - The best gear ratios.
 - The best voltage for your motor.
 - How you should drive to maximize efficiency and/or speed.

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Chart Overview



ME0909

36V CW 09.9.23

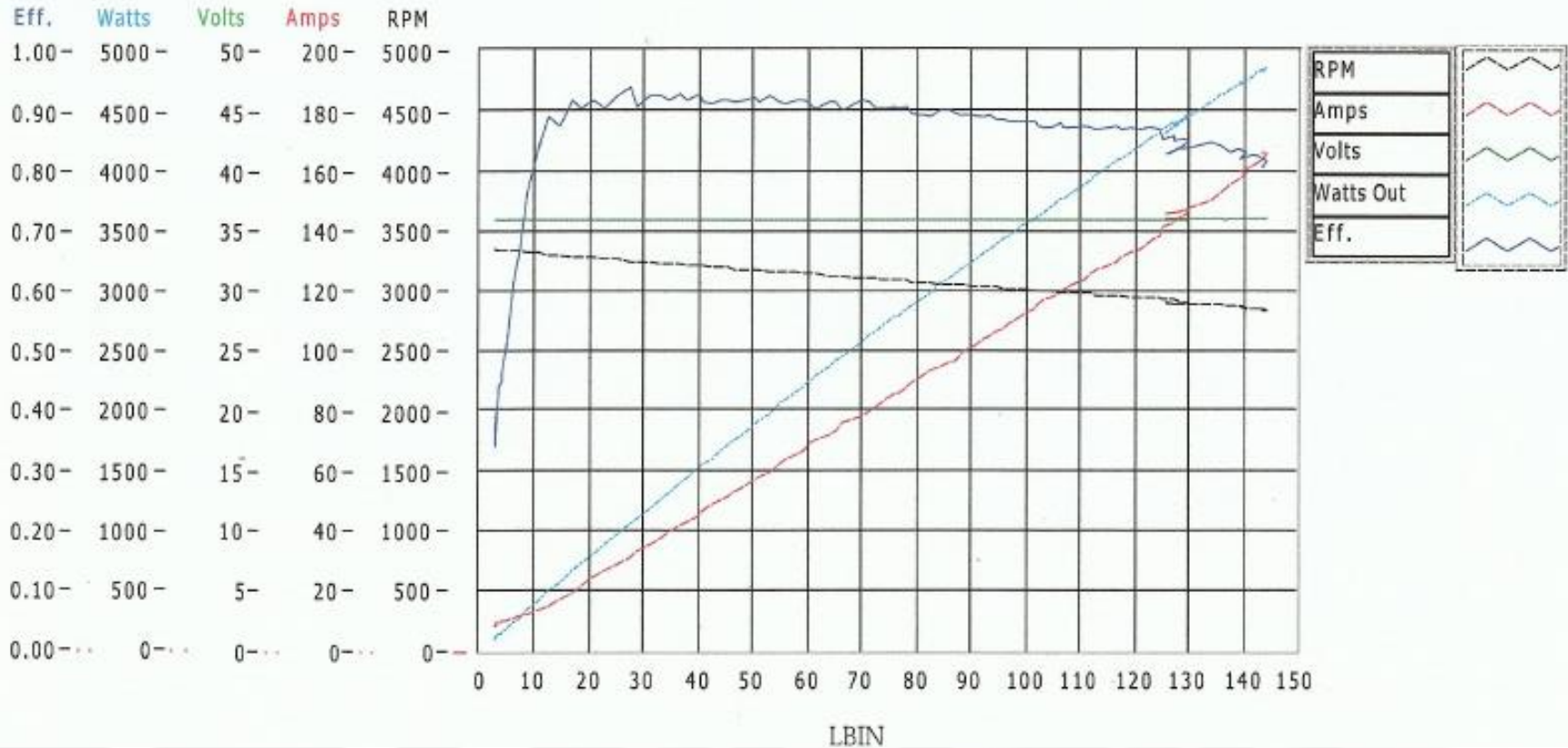


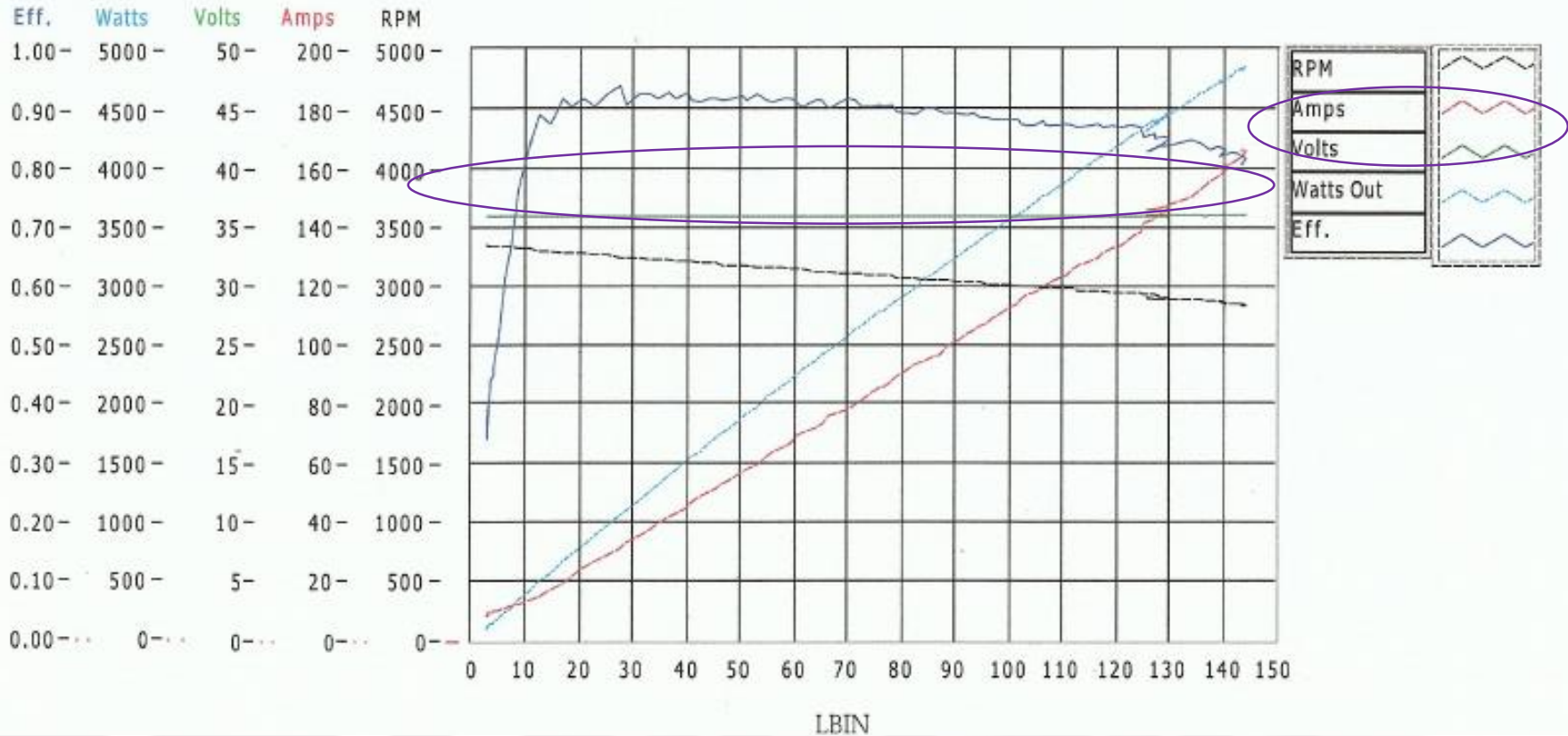
Chart is generated by running motor at a specific voltage, while attached to a clutch, and slowly increasing torque (a-axis). Everything else is measured, can be difficult to read focus on 1 thing at a time.

Voltage



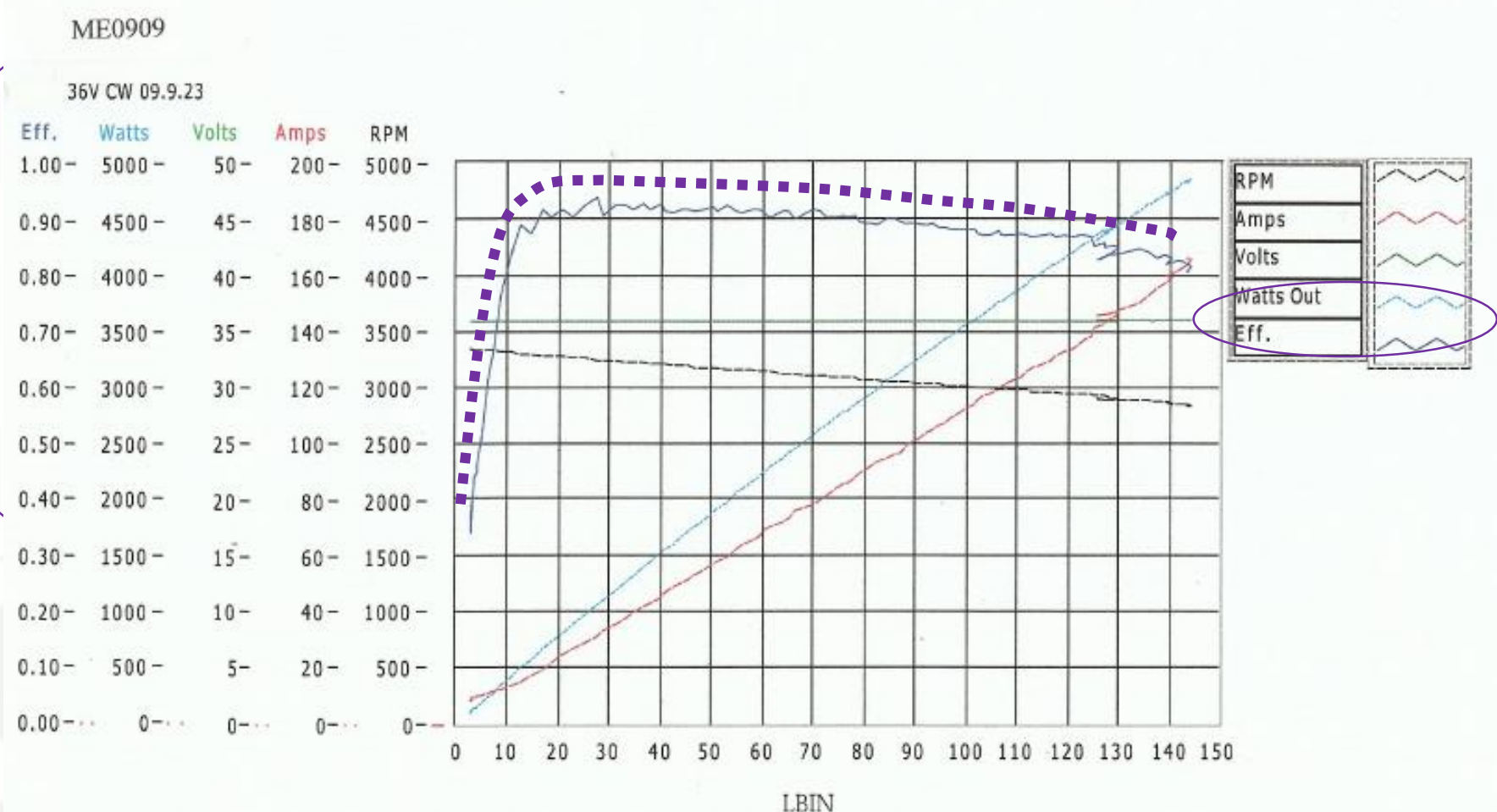
ME0909

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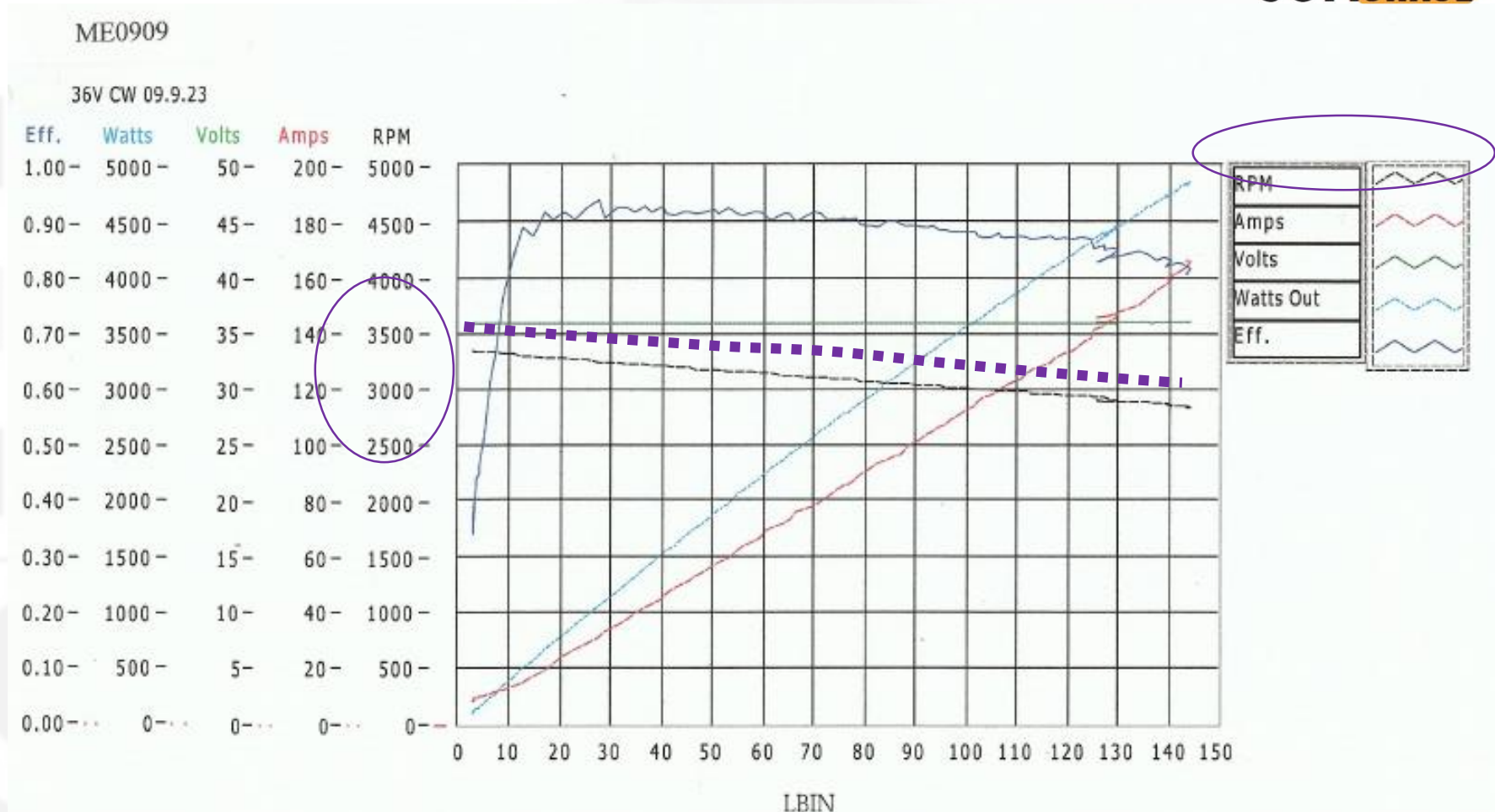
We can see from the header, that this is the curve for the Mar 0909 motor @ 36V, and the voltage is held constant for the duration of the test (green line).

Efficiency



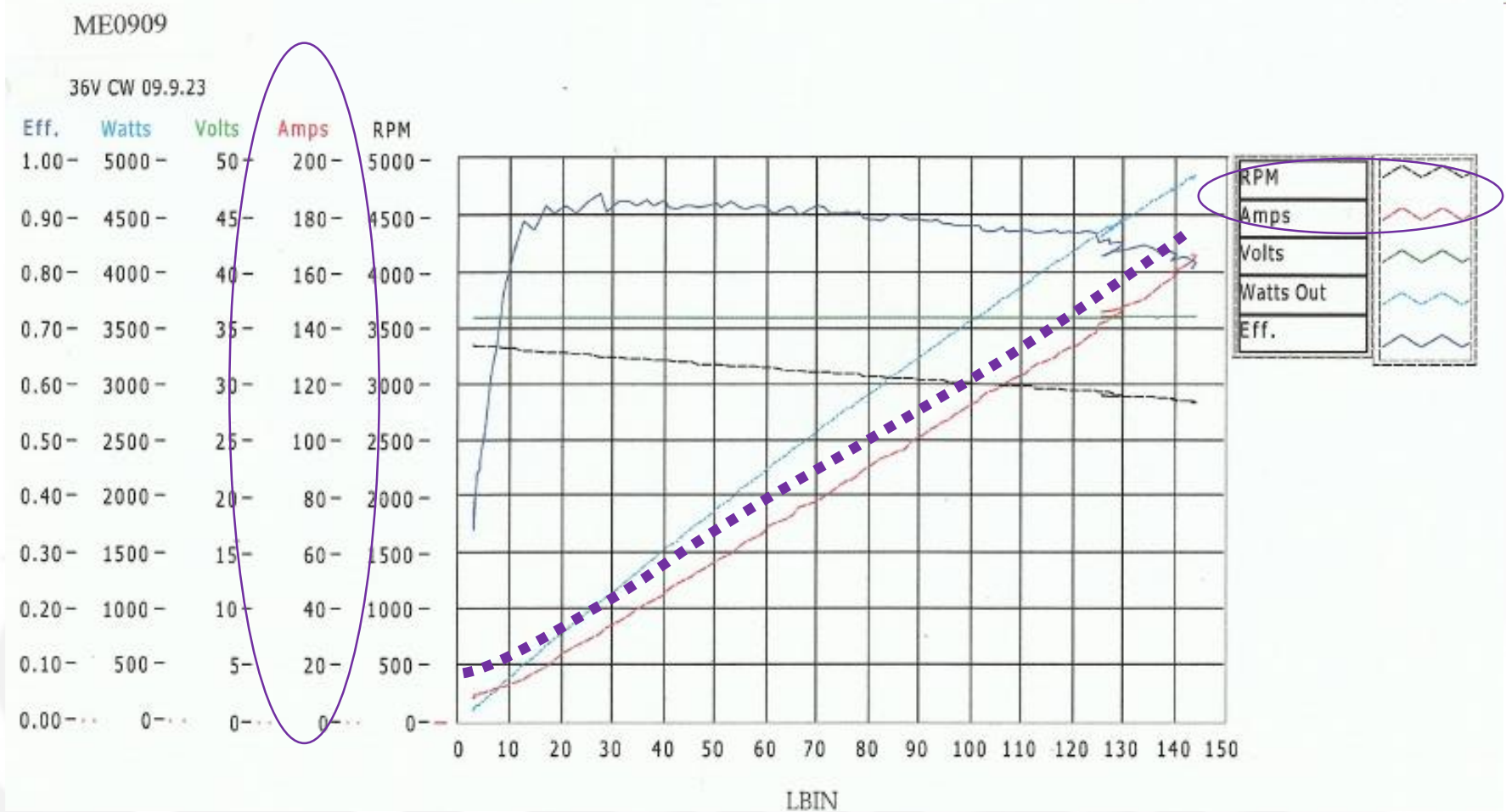
The efficiency starts low (motor free-spinning) then quickly increases, before slowly falling. The peak efficiency seems to be between 20 and 40 inch pounds, but increasing changes in torque (up to around 120 pound inches) don't have a big effect.

Rotations Per Minute (RPM)



For this test the speed decreases slowly as the torque increases. If we want to increase motor speed, we will need to run the motor at a higher voltage.

Current (Amps)



If we expect to get 140 pound inches of torque, our electrical system is going to have to produce around 160 Amps of current (which is a lot). We want to make sure our electrical components are capable of handling this much current (for short periods of time).

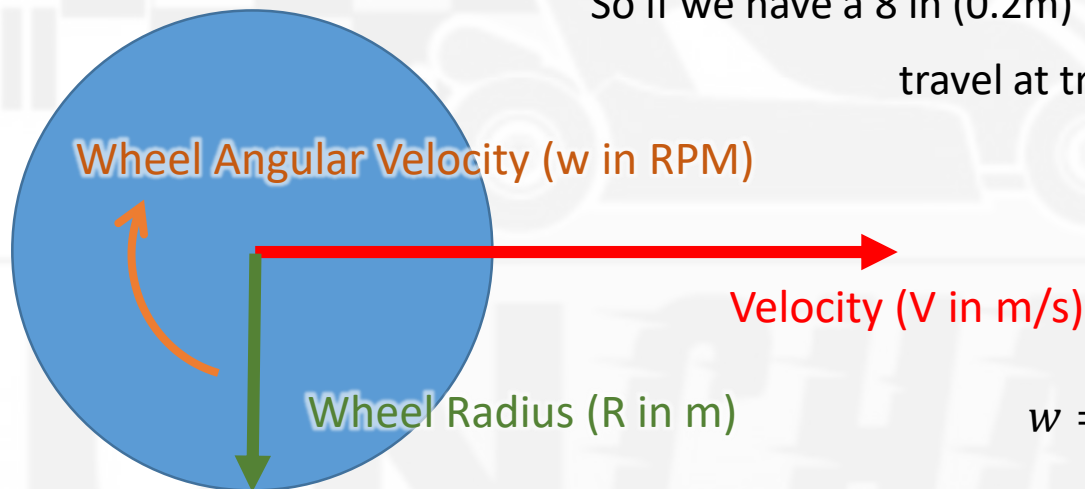


Motor Speed Calculations

- Velocity and Gear Ratio:

$$V = w \left(\frac{\text{rotations}}{\text{minute}} \right) * \frac{2\pi \text{ radians}}{1 \text{ rotation}} * \frac{1 \text{ minutes}}{60 \text{ seconds}} * R(\text{meters})$$

So if we have a 8 in (0.2m) radius wheel and want to travel at travel at 20 mph (8.9 m/s).



$$w = \frac{8.9 \frac{m}{s}}{\frac{2\pi}{60} * 0.2 m}$$

$$w = \frac{8.9}{0.01 * 0.2} = 445 \text{ RPM}$$

If we want a motor speed of about 3000 RPM @ 20 mph, then we need a total gear ratio of

$$\text{Gear Ratio} = \frac{w_{\text{wheel}}}{w_{\text{motor}}} = \frac{3000}{445} = 6.7$$