

Electric Vehicle Technology



TESLA

Introduction

- What is a Tesla?
 - An all electric car created by Tesla Motors
 - It's not a hybrid - you don't put gasoline in the car, it has no engine, it has no tailpipe
- Charging the Battery
 - Plug it into a 240 volt wall outlet at home (1/3 the cost of gasoline)
 - Use Supercharger Stations on the road (Superchargers provide up to 170 miles of range in as little as 30 minutes)

Introduction continued...

- An iPad-like touch screen activates various functions of the car
- Your smartphone can interact with the Tesla
 - It can tell you where your car is parked,
 - How much longer it will be until the battery is charged,
 - Or turn on the heater or A/C before returning to your vehicle
- Safety Features
 - Because the Tesla has no engine, the front end becomes a crumple zone
 - Battery pack located underneath the car creates a very low center of gravity
- A fully electric car releases no greenhouse gases or toxic fumes

Tesla Model 3 Touchscreen



September 2017

R. W. Dilorio

Annual Service Inspection

Unlike gasoline cars, Tesla vehicles requires no oil changes, fuel filter, spark plug replacements, or emission checks. As an electric car, even brake pad replacements are rare because most braking energy is regeneratively captured by the motor and returned to the battery.

	Year 1 12,500 miles	Year 2 25,000 miles	Year 3 37,500 miles	Year 4 50,000 miles
Multi point inspection (w/tire rotation and alignment check)	X	X	X	X
Cabin air filter replacement	X	X	X	X
Wiper blade set replacement	X	X	X	X
Key fob battery replacement (set)	X	X	X	X
Brake fluid replacement		X		X
A/C service		X		X
Battery coolant replacement				X
Service cost	\$400	\$700	\$400	\$900

History

- Tesla
 - Tesla founded in 2003
 - 2008 Musk becomes CEO
 - Tesla sold 2,250 Roadster models between 2008 and 2012.
 - Tesla went public in 2010, the first American car company to do so since Ford Motor Company in 1956.
 - 2012 Supercharger station network introduced
 - First deliveries of the Model S June of 2012
 - Tesla introduces dual motor models of the Model S in January 2015
 - First deliveries of the Model X September of 2015
 - Tesla takes reservations for the Model 3 on March 31, 2016
 - Model 3 delivered to first 30 customers on July 28, 2017
- Elon Musk
 - Co-founder of Paypal
 - Musk received \$165 million when Paypal was sold to Ebay in 2002
 - Musk invested every penny into a new company, Space X
 - Elon Musk is one of the founders of SolarCity (merged with Tesla Motors in November 2016)

Tesla Specifications

- **Model S: \$71,000-\$141,500**
- P100D - range: 315 miles, 0-60 in 2.5 seconds 155 mph
- 100D - range: 335 miles, 0-60 in 4.1 seconds 155 mph
- 75D - range: 259 miles, 0-60 in 4.2 seconds 140 mph
- 70 (rear drive)- range: 249 miles, 0-60 in 4.3 seconds 140 mph
-
- **Model X: \$79,500-\$145,000**
- P100D - range: 289 miles, 0-60 in 2.9 seconds 155 mph
- 100D - range: 295 miles, 0-60 in 4.7 seconds 155 mph
- 75D - range: 237 miles, 0-60 in 4.9 seconds 130 mph
-
- **Model 3: \$35,000-\$44,000**
- range: 220-310 miles, 0-60 in 5.1-5.6 seconds 130-140 mph

Software

- Tesla vehicles receives over the air software updates that add new features and service updates
- Real time energy consumption and range estimation
- Calendar synchronization for daily schedule and tap to navigate
- Wi-Fi and Internet connectivity, Internet streaming radio and AM, FM

Li-Ion Battery Pack

- Thousands of cells
 - Other automaker use specialized large format Li-Ion cells
 - Tesla's battery pack is made up of thousands of inexpensive commodity cells similar to those found in laptops.
 - Even including the overhead of the pack enclosure, connections between cells in modules, sensors, and circuitry, Tesla has a lower pack cost than any other maker of plug-in electric cars.

Li-Ion Battery Pack continued...

- Simplifying a cheap cell
 - Tesla also redesigned its cell to be much less complex by removing expensive safety systems built into each individual cell.
 - When used as a laptop battery, each cell requires a safety mechanisms to prevent fires.
 - But in a large, electronically-controlled, liquid-cooled battery pack like the one used in Tesla vehicles, the safety features on each cell would be redundant.

Tesla Battery Pack



September 2017

R. W. Dilorio

Tesla Gigafactory

- The **Tesla Gigafactory 1** is a lithium-ion battery factory located south of Reno, NV.
- The factory became operational in the first quarter of 2016.
- It is the world's largest building by physical area and the second-largest building by usable space, only smaller than the Boeing Everett Factory.
- Tesla expects that Gigafactory 1 will reduce the production cost for their electric vehicle batteries and Powerwalls by 30%.
- The factory will employ approximately 6,500 people and supply 500,000 Tesla cars per year.

Tesla Gigafactory 1 (south of Reno, Nevada)



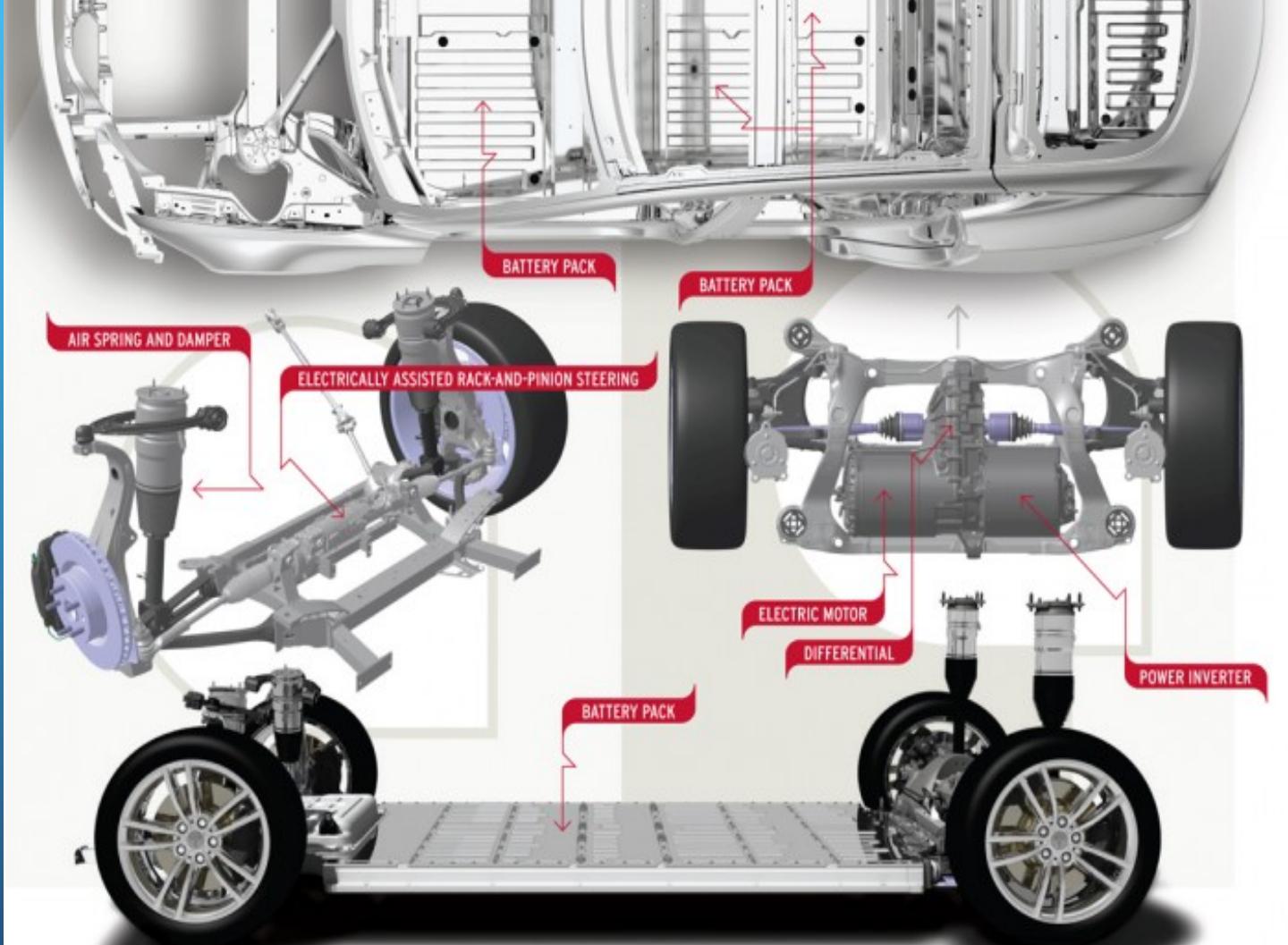
September 2017

R. W. Dilorio

AC Induction Motor

- The AC induction motor is relatively cheap to make, and power electronics for automotive applications have come down in price significantly over the past 20 years. Regenerative braking comes essentially for free.
- With an inverter it becomes possible to power an induction motor from a battery or other DC source
- Variable speed also becomes possible simply by adjusting the inverter frequency.
- Today, all the hybrids are powered by DC brushless drives, with no exceptions. Tesla vehicles instead use induction drives.

Tesla Model S Assembly



Regenerative Braking

- When you take your foot off the accelerator, the car will begin to slow down almost immediately.
- This occurs because the electric motor is transformed into a generator when power from the battery is removed.
- The motor turned generator produces an electric current that is sent back to the battery to recharge it.

How Does an Electric Vehicle Work?

<https://youtu.be/3SAxXUlre28>

Electric Car Charging 101

- **Level 1 Charger** (120v std household, 1.4 kW): 4 miles per hour of charge
- **Level 2 Charger** (240v, 7.7 kW): 25 miles per hour of charge
- **Level 3 Charger (DC) - CHAdeMO (50 kW)** - 75-100 miles in 30 minutes
- **Level 4 Charger (DC)- Supercharger (90kW)** 170 miles in 30 minutes
- 900 Supercharger Stations with 6,058 Superchargers in North America

Supercharger Station



September 2017

R. W. Dilorio

Enhanced Autopilot

- Enhanced Autopilot provides the capability
 - to match speed to traffic conditions
 - keep within a lane
 - automatically change lanes without requiring driver input
 - transition from one freeway to another
 - exit the freeway when your destination is near
 - self-park when near a parking spot
 - and be summoned to and from your garage.
- Enhanced Autopilot also provides front and side collision avoidance and automatic emergency braking.

Full Self-Driving

- Full Self-Driving will enable short and long distance trips with no action required by the driver.
- Your Tesla will
 - navigate urban streets (even without lane markings)
 - manage complex intersections with traffic lights, stop signs and roundabouts
 - and handle densely packed freeways with cars moving at high speed.
- When you arrive at your destination simply step out at the entrance
 - and your car will enter park seek mode and automatically search for a spot and park itself
 - a tap on your phone summons it back to you.

Sensors

- Eight surround cameras
- Twelve updated ultrasonic sensors
- A forward-facing radar provides additional data about the world that is able to see through heavy rain, fog, dust and even the car ahead.
- To make sense of all of this data, a new onboard computer with over 40 times the computing power of the previous generation (initial autopilot version) runs the new Tesla-developed neural net for vision, sonar and radar processing software

Sensors continued ...

- Radar
- Narrow Forward Camera
- Main Forward Camera
- Wide Forward Camera
- Forward Looking Side Cameras
- Rearward Looking Side Cameras
- Rear View Camera
- Ultrasonic sensors

Autonomous Mode Onboard Computer

- **Artificial Intelligence** provides the rules for safe driving in various situations and environments
- **Deep Learning Neural Networks** are used for pattern recognition based on the probability of a pattern match
- **NVIDIA Drive Px2 Computer** takes the output of the various sensors to “see” the objects surrounding the car

Current Electric Vehicles

BEV	Range (miles)	HP	Acceleration (0-60 mph)	Top speed (mph)	Cost (\$)
Ford Focus Electric	76	143	10.1	84	29,170
BMW i3	81	170	7.0	93	42,400
Volkswagen e-Golf	83	115	10.1	87	28,995
Fiat 500e	93	111	8.7	85	31,800
Kia Soul EV	93	109	9.2	90	31,950
Mercedes B-class, B250e	101	177	7.9	101	41,450
Nissan Leaf SL	107	107	10.2	100	36,790
Chevrolet Bolt*	200	200	7.0	91	37,500
Tesla Model 3 (RWD)**	215	-	<6.0	-	35,000
Tesla Model S (AWD)	265	691	2.8	155	81,000
Tesla Model X (AWD)	275	763	3.2	155	85,500

**Supercharger stations have been built along major highways

*Chevy does not plan to provide a charging station network

2018 Model 3



September 2017

R. W. Dilorio

Model 3 Interior



September 2017

R. W. Dilorio

Model 3 Standard Equipment

Standard Battery

- Range: 220 miles (EPA estimated)
- Supercharging rate: 130 miles of range per 30 minutes
- Home charging rate: 30 miles of range per hour (240V outlet, 32A)

Performance

- 0-60 mph: 5.6 seconds
- Top speed: 130 mph

Interior

- 15" touchscreen display
- FM/Internet streaming radio

Standard Equipment continued ...

Convenience

- Onboard maps and navigation
- Wi-Fi and LTE internet connectivity
- Keyless entry and remote climate control using the Tesla app
- Voice activated controls
- Bluetooth hands-free calling and media streaming
- Back-up camera
- Auto dimming rear-view mirror

Standard Equipment continued ...

Safety

- Full LED exterior lighting
- Eight cameras, forward radar and twelve ultrasonic sensors enabling active safety technologies including collision avoidance and automatic emergency braking
- Six front row and two side curtain airbags
- Three-point safety belts with belt-reminders for driver and four passengers
- Electronic stability and traction control

Standard Equipment continued ...

- Four-wheel antilock disc brakes with electronic parking brake
- Child safety locks
- Anti-theft alarm system
- Tire pressure monitoring system

Warranty

- Vehicle: 4 year, 50,000 mile limited warranty
- Battery warranty: 8 year, 100,000 mile

Standard Equipment continued ...

Vehicle Specifications

- Length: 184.8”
- Width: 76.1” (72.8” with mirrors folded)
- Height: 56.8”
- Wheelbase: 113.2”
- Seating capacity: 5 adults
- Luggage capacity: 15 cubic feet
- Curb weight:
 - 3549 lbs. (Model 3)
 - 3814 lbs. (Model 3 Long Range)