

WORK-ENERGY-POWER

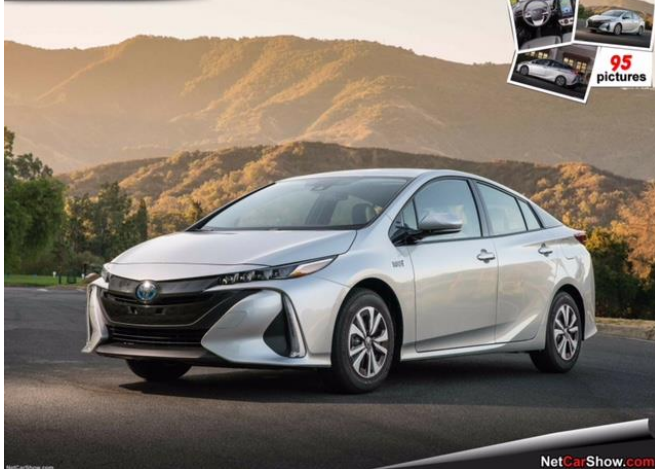
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Dedicated to Dr. Michael D. Cise, Nuclear & Chemical Engineer of Arizona & Indiana who drives a smart efficient Prius.

Doing the Math on Toyota's Prius Prime Hybrid

2017 Toyota Prius Prime



2017 Toyota Prius Prime

Charge the battery and the Prime drives like an electric car.

Once the battery is spent, after about 25 miles, the car drives like any other Prius.

As otherworldly as the Prius Prime looks, it's not the offspring of the Transformers leader Optimus. It's Toyota's plug-in hybrid variant. The concept is simple: **Charge the battery and it drives like an electric car. Once the battery is spent, the Prime drives like any other Prius. Easy peasy.** It's not Toyota's first plug-in. My neighbor has the first one, based on the third-generation Prius, and she has been disappointed with its real-world all-electric range of 11 miles. Prime, riding on Toyota's new scalable chassis architecture, rectifies that. Toyota claims up to 25 miles in E.V. mode. I saw 24, restraining my inner Mario Andretti. Math class is in session. Don't groan: Numbers are important to plug-ins. Prime's main competitor, the Chevrolet Volt, is rated by the Environmental Protection Agency at 53 electric-only miles. Over all, the Chevy is less efficient, at 106 miles per gallon equivalent and a 42 m.p.g. average on gasoline alone, compared with **(((Prime's 133 m.p.g. equivalent and 54 m.p.g. average on gasoline alone.)))** The Hyundai Ioniq plug-in hybrid, available late this fall, is estimated at 27 electric miles. **Car and Driver clocks 0-to-60 miles an hour in 10.2**

in hybrid mode. Both Prius and Prius Prime get a 1.8-liter 4-cylinder gas engine. Prime uses the same two electric motor/generators as a standard Prius does (a motor becomes a generator when turning in reverse). **Total system power to the front tires is 121 horsepower.** Toyota recommends a dedicated 15-amp circuit to charge Prime on 120-volt current (taking about five and a half hours if the battery is fully spent). On 240 current, it's two hours and 10 minutes. All but the \$27,985 Plus model get an expansive 11.6-inch LCD touch screen. Is 25 miles of electric range enough (assuming the E.P.A. figure is close to actual performance

Back to New York Times Application site: <http://CisePhysics.homestead.com/files/NYTPHysics2016E.pdf>

INTRODUCTION: This Prius Prime output power(P_{OUT}) goes into doing (output work/unit time) where

W_{OUT} = Useful kinetic energy = $\frac{1}{2} m v^2$. Thus $P_{OUT} = \frac{1}{2} m v^2/t$ and since

$$X = \text{efficiency} = P_{OUT}/P_{input},$$

$$X = [\frac{1}{2} m v^2]/t(P_{INPUT})$$

QUESTIONS: (a) Find mass of 3365 lb. Prius Prime car ? (b) Convert Prius Prime's HP to ft. lb./s.? (c) Find efficiency X of Prius Prime ?, (d) Does this efficiency seem reasonable for this vehicle?

HINTS: $W = mg$, $g = 32 \text{ ft./s.}^2$, $60 \text{ mph} = 88 \text{ ft./s.}$, $550 \text{ ft. lb./s.} = 1 \text{ HP}$

ANSWERS: (a) $m = 105.16 \text{ slugs}$, (b) $P_{INPUT} = 66,550 \text{ ft. lb./s.}$, (c) $\sim 60\%$ (d) Efficiency of electric-hybrid's are usually 2-3 times more efficient than none turbo gasoline engines. This author's old 1999 Astro is only 15% - 20% efficient. Thus, a computed 60% is in the range: 2 - 3 more