

The Loyal Engineers Steering NASA's Voyager Probes Across the Universe



Larry Zottarelli, who recently retired from the Voyager flight crew.

INTRODUCTION 1: Function of this application is to first find escape velocity from earth.

Second: Verify the two Voyager spacecraft have exceeded escape velocity.

Energy of rocket at launch: $\frac{1}{2}mv_i^2 - GmM/R_e = \frac{1}{2}mv_f^2 - GmM/R_{\infty}$ (energy @ infinity)

Since at infinity: $1/R_{\infty} = 0$, $v_f = 0$, Thus: $\frac{1}{2}mv_i^2 = GmM/R_e$, Thus, $v_i = [2GM_e/R_e]^{1/2}$

G = gravitational constant = $6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$, $M_e = 2 \times 10^{24} \text{ kg}$, $R_e = 6.371 \times 10^6 \text{ m}$

QUESTION 1: Find escape velocity from earth. Exceeding this speed = craft can't return.

ANSWER: $v_{\text{escape}} = \sim [11.206 \times 10^3 \text{ m/s.}](2.237 \text{ mph/9m./s.}) = \sim 25,073 \text{ mph}$

In the early spring of 1977, Larry Zottarelli, a **(((40-year)))**-old computer engineer at NASA's Jet Propulsion Laboratory in Pasadena, set out for Cape Canaveral, Fla., in his Toyota Corolla. A Los Angeles native, he had never ventured as far as Tijuana, but he had a per diem, and he liked to drive. Just east of Orlando, a causeway carried him over the Indian and Banana Rivers to a triangular spit of sand jutting into the Atlantic, where the Air Force keeps a base. His journey terminated at a cavernous military hangar. A fleet of JPL trucks made the trip under armored guard to the same destination. Their cargo was unwrapped inside the hangar high bay, a gleaming silo stocked with tool racks and ladder trucks. Engineers began to assemble the various pieces. Gradually, two identical spacecraft took shape. They were dubbed Voyager I and II, and their mission was to make the first color photographs and close-up measurements of Jupiter, Saturn and their moons. Then, if all went well, they might press onward — into uncharted territory. It took six months, working in shifts around the clock, for the NASA crew to reassemble and test the spacecraft. As the first launch date, Aug. 20, drew near, they folded the camera and instrument boom down against the spacecraft's spindly body like a bird's wing; gingerly they pushed it, satellite dish first, up inside a metal capsule hanging from the high bay ceiling. Once "mated," the capsule and its cargo — a probe no bigger than a Volkswagen Beetle that, along with its twin, had nevertheless taken 1,500 engineers five years and more than \$200 million to build — were towed to the launchpad.



A test model of Voyager in 1977

INTRODUCTION 2: Second goal is to see if voyagers have exceeded the escape velocity.

QUESTIONS: (a) Convert 40 years into seconds?, (b) Find speed of Voyager 1 & 2 in mph?
(c) Did Voyager 1 & 2 exceed escape velocity?

HINTS: 365 days/yr., 24 hrs./day, $x = vt$

ANSWERS: (a) $3.504 \times 10^5 \text{ s.}$, (b) $V_1 = 28,540 \text{ mph}$, $V_2 = 37,100 \text{ mph}$, (c) Yes! > Escape velocity

Today the Voyagers are **(((10 billion and 13 billion miles away))), the farthest man-made objects from Earth. The 40th anniversary of their launch will be celebrated next month.** The mission quite possibly represents the end of an era of space exploration in which the main goal is observation rather than commercialization. In internal memos, Trump-administration advisers have referred to NASA's traditional contractors as "Old Space" and proposed refocusing its budget on supporting the growth of the private "New Space" industry, Politico reported in February. "Economic development of space" will begin in near-Earth orbit and on the moon, according to the president's transition team, with "private lunar landers staking out de facto 'property rights' for Americans on the moon, by 2020."



full-scale Voyager model at the JPL in Pasadena, Calif.