CENTRIPETAL FORCE FROM GRAVITY

Units 14 & 8, Dr. John P. Cise, Professor of Physics, Austin Com. College, Austin, Texas USA, jpcise@austincc.edu & NYTimes 4/11/19 by K. Chang. Dedicated to Ed Nye

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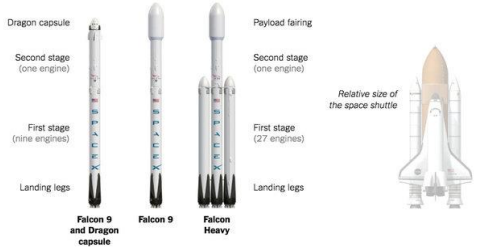
Falcon Heavy, SpaceX's Giant Rocket, Launches Into Orbit, and Sticks Its Landings

It was only the second flight for what is the most powerful rocket now available on Earth, improving

After the launch of the most powerful rocket in operation, all three of its boosters safely touched down on Earth.

The Falcon Heavy roared into space on Thursday night, arcing atop three columns of flame toward orbit with a large satellite on board. It was the second launch for what is the most powerful rocket in operation today, a reminder of its majestic test launch fourteen months ago from the same launchpad, 39A, at NASA's Kennedy Space Center in Florida. ***The Falcon Heavy's cargo was mundane, but also more useful: Arabsat-6A, a Saudi Arabian communications satellite which will relay television, (((internet and mobile phone signals to the Middle East, Africa and Europe))).*** Shortly after the launch, the rocket's three boosters returned to Earth. Two touched down seconds apart at landing pads at Cape Canaveral, not far from the launchpad. The center booster, which went higher and farther, set down on a floating platform in the Atlantic Ocean. The side booster rockets from Falcon Heavy successfully landed side-by-side at landing pads at Cape Canaveral, not far from the launchpad where the mission blasted off.



The side booster rockets from Falcon Heavy successfully landed side-by-side at landing pads at Cape Canaveral, not far from the launchpad where the mission blasted off.CreditJoe Skipper/Reuters Sticking that third landing was an advancement for SpaceX, after a similar maneuver failed in 2018 on the first try. The booster then missed the platform, hitting the water at more than 300 miles per hour.

Why is Falcon Heavy different from other SpaceX rockets?The company's workhorse is the Falcon 9 rocket, which first launched in 2010. The first stage of the Heavy essentially consists of three Falcon 9 first stages bound together. The second stages of the two rockets are identical.The additional thrust allows the Heavy to propel 140,000 pounds to low-Earth orbit, nearly three times what the Falcon 9 can lift. **How does this Falcon Heavy differ from the first one?** On the test flight, the two side boosters were older versions reused from earlier flights. (SpaceX's best innovation to date is landing the booster stage of its rockets and launching it again; traditionally, rockets have been one-use throwaways, with the booster stages dropped into the ocean.) For this one, the side boosters had never before been used. They were the latest version of the rocket, called "Block Five." ("Block" is what rocket companies call a major upgrade.) That boosts the thrust and how much the Falcon Heavy can carry. **Why did the second Falcon Heavy flight take so long?** Even though the first Falcon Heavy flight appeared to be nearly flawless, SpaceX probably made adjustments. That, after all, is the reason a rocket company performs a test flight for a new rocket design. SpaceX also has had a backlog of Falcon 9 missions to fly. **It launched 20 Falcon 9 missions in 2018,** more than in any previous year, in addition to the one Falcon Heavy launch. The company was also busy at work developing its Crew Dragon capsule for taking NASA astronauts to and from the International Space Station.The market for the Falcon Heavy is also much smaller than once envisioned. In the years since, improvements have made the Falcon 9 more powerful, and miniaturization of electronics has shrunk the size of many satellites. The **Falcon Heavy is now needed for only the largest satellites like the 13,000-pound Arabsat-6A satellite, which is (((headed to geosynchronous orbit more than *22,000 miles above Earth.*))) The satellite could have been launched on Falcon 9, but with the Heavy thrust , the satellite could use less of its own fuel to reach its final orbit, extending itslifetime.**

INTRODUCTION: Gravity supplies centripetal force to keep satellites in orbit: $G m M_e/R^2 = m V^2/R$, Thus $M_e = [4\pi^2/G](R^3/T^2)$
Where $M_{earth} = 5.972 \times 10^{24}$ kg., $G = 6.67 \times 10^{-11}$ N $m^2/kg.^2$, $R = R_{earth} + h$, $R_{earth} = 6356 \times 10^3$ m, h = height above earth,
$V = R\ 2\pi/T$
T = period of earths rotation = 1 day. Geosynchronous satellites have same period as earth & stay at same designated point above earth.
QUESTIONS: (a) Find T in seconds? Note: 24 hr./day, 3600 s./hr., (b) Find R in meter units?, (c) Find h in meter units?
(d) Find h in miles? Show all calculations very clearly to get credit. Use many pages if need be. HINTS: 0.0006213 miles/m.

ANSWERS: (a) 8.64×10^4 seconds , (b) 4.223×10^7 m , (c) h = $35,874 \times 10^3$ meters, (d) h = ~ 22,288 miles CLOSE