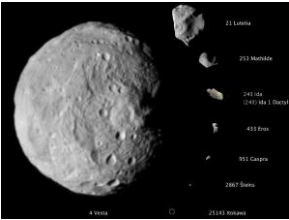


Today's Class: Asteroids

- Reading on Pluto & the Kuiper Belt – Sections 12.1, 12.2, & 12.5 in **Cosmic Perspective**.
- Homework #6 is due on Friday.
- Exam #3 on Monday:
 - * All the reading since Oct. 26th through Nov. 20th.
 - * All homework assignments.
 - * All material discussed in class including in-class group exercises.
 - * You may use one page (front + back) of notes.
 - * Use a calculator not on your phone.
 - * Study with another member in the class, if possible



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1

SpaceX Crew Dragon Capsule Docks at International Space Station with its 1st Crew of 4

Presented by Payton Godlewski

- 27 hour mission results in arrival of 3 NASA astronauts and 1 Japanese astronaut
- Resilience is first commercial spacecraft to bring astronauts for long-duration stay
- First time for 7 astronauts aboard instead of 6
- SpaceX's Crew Dragon has been approved by NASA for regular flights to and from the ISS
- Resupply missions also contracted to SpaceX
- Dragons constantly in orbit, with 7 missions planned over 15 months
- Boeing still working on a successful test flight
- Fun Fact: There was also a Baby Yoda plushie onboard, which acted as a zero-gravity indicator

Question: Now that SpaceX has proven to be successful, what does this mean for the future of commercialization of space travel? SpaceX has already been contracted whereas Boeing lacks a successful spacecraft, what could this mean for their future?



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2

Last Class

- Overview of Uranus & Neptune.
 - Densities & Interiors of Jovian planets.
 - Atmospheres of Ice Giants compared to Gas Giants.
- The moons of Uranus & Neptune
 - Triton

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3


Today's Class

- Overview of asteroids
 - Asteroid moons & calculating densities
 - Orbits & Locations of asteroids
 - Origin of the asteroid belt
- The OSIRIS-REx sample return mission.

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4

Asteroids

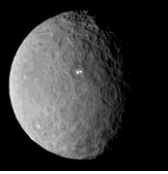


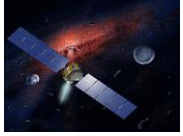
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6

Asteroid Facts

Dawn image of Ceres from 46,000 km, 19 February 2015





Artist's rendering of Dawn with Vesta (left), Ceres (right), and numerous fictitious smaller asteroids. In reality, only one asteroid would be visible at a time.

- Asteroids are rocky leftovers of planet formation.
- The largest is Ceres (dwarf planet?), diameter ~1000 kilometers, currently being surveyed by U.S. Dawn spacecraft.
- 150,000 in catalogs, and probably over a million with diameter >1 kilometer.
- Small asteroids are more common than large asteroids.
- All the asteroids in the solar system would add up to at most a very small terrestrial planet.

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Vesta as seen by the Dawn Spacecraft

Vesta is much wider (across the equator) than it is tall...
...in part because a huge impact gouged out a crater near its south pole.

Equatorial view South pole view

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8

Asteroids are cratered and not round

10 km

Size of the Moon to scale

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9

Asteroids with moons

Ida (Galileo) Dactyl (Galileo)

- Some large asteroids have their own moon.
- Asteroid Ida has a tiny moon named Dactyl.

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10

Class Exercise

Is an asteroid impact a serious threat to the Earth and to our civilization?

video

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11

Density of Asteroids

139 km

approximate size of Eugenia

asteroid moon orbital path of moon

- Measuring the orbit of asteroid's moon tells us an asteroid's mass.
- Mass and size tell us an asteroid's density.
- Some asteroids are solid rock; others are just piles of rubble.

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12

Asteroid Orbits

Trojan asteroids Jupiter Trojan asteroids

Mars

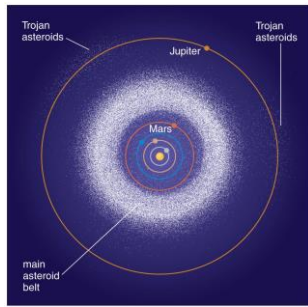
main asteroid belt

- Most asteroids orbit in the *asteroid belt* between Mars and Jupiter.
- *Trojan asteroids* follow Jupiter's orbit.
- Orbits of *near-Earth asteroids* cross Earth's orbit.

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13

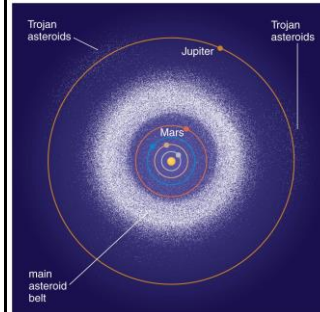
Why is there an asteroid belt?



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14

Origin of Asteroid Belt



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- Rocky planetesimals between Mars and Jupiter did not accrete into a planet.
- Jupiter's gravity, through influence of orbital resonances, stirred up asteroid orbits and prevented their accretion into a planet.

16

OSIRIS-REx grabs a sample



The **Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer** (OSIRIS-REx) spacecraft traveled to a near-Earth asteroid, called Bennu, and is bringing possibly a 4 lb sample back to Earth for study. The mission will help scientists investigate how planets formed and how life began, as well as improve our understanding of asteroids that could impact Earth.

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[video](#)

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