

# Space Stations

Osher, Fall 2024

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# Background

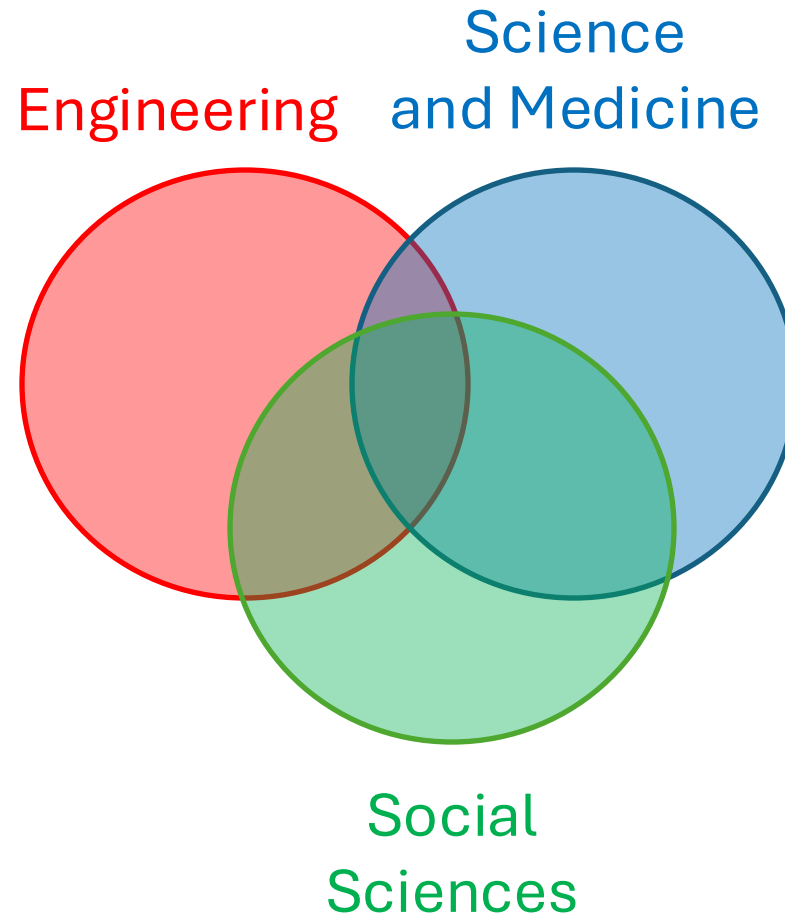
- My background / your background
- What does “space station” mean to you?
- What do you want to learn?

# Course Goals

What? When?

Where? Who?

How? Why?



# Outline

- **Week 1: Science and Science Fiction Background**
- Week 2: Early Space Stations
- Week 3: Mir, ISS Planning and Construction
- Week 4: The ISS Operations
- Week 5: China, Science & Tech Summary, and the Future

## Quotes from *Orbital*, A Novel by Samantha Harvey

“Some alien civilisation might look on and ask: what are they doing here? Why do they go nowhere but round and round? The Earth is the answer to every question. The Earth is the face of an exulted lover; they watch it sleep and wake and become lost in its habits. The Earth is a mother waiting for her children to return, full of stories and rapture and longing. Their bones a little less dense, their limbs a little thinner. Eyes filled with sights that are difficult to tell.”

“They thought they’d find it precarious, this fact of living in a complex life-support machine. A fire, an ammonia leak, radiation, a meteor strike. And in moments they do – but generally not so, and anyway, all beings are living in life-support machines commonly called bodies and all of these will eventually fail.... When they leave, they will feel less safe.”

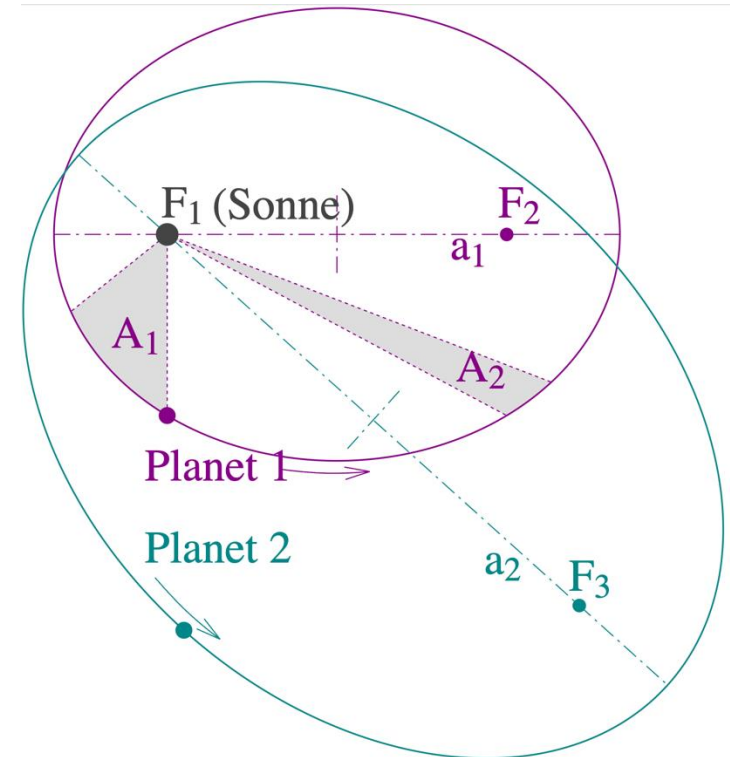
# Today's Class

- Some science history and background
- Science fiction
- Build-up to the first stations
- Orbital mechanics of rendezvous and docking

# Johannes Kepler (1571-1630)

## Three laws of planetary motion

- The orbit of a planet is an ellipse with the Sun at one of the two foci
- A line segment joining a planet and the Sun sweeps out equal areas during equal intervals of time
- The square of a planet's orbital period is proportional to the cube of the length of the semi-major axis of its orbit



# Sir Isaac Newton (1642-1726)

- Universal Laws of Motion
  - Inertia: A body stays at rest or continues in motion in a straight line unless acted upon by a force
  - $F=ma$ : The force on an object is equal to its mass times its acceleration (also equal to the rate of change of momentum)
  - Equal and opposite reactions: The mutual action of two bodies acting upon each other is equal and opposite (conservation of momentum)

[Science Center Houston: Newton's Third Law](#)

NASA astronauts Mark Vande Hei and Joe Acaba on the ISS [1:15]

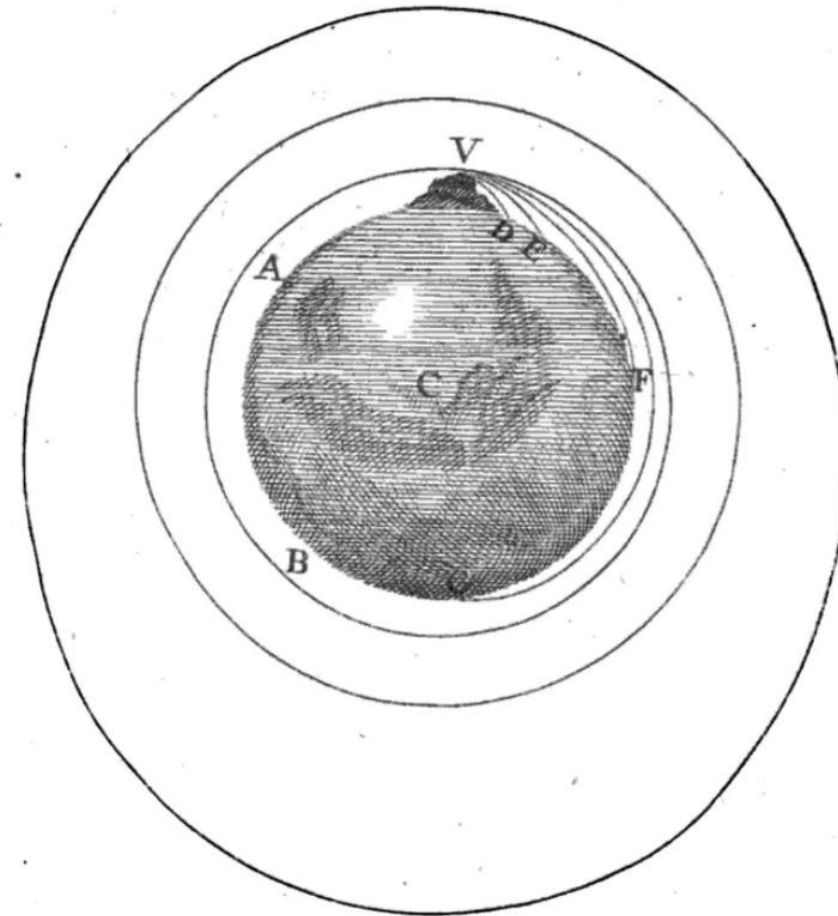


# Newton, continued

- Universal law of gravitation

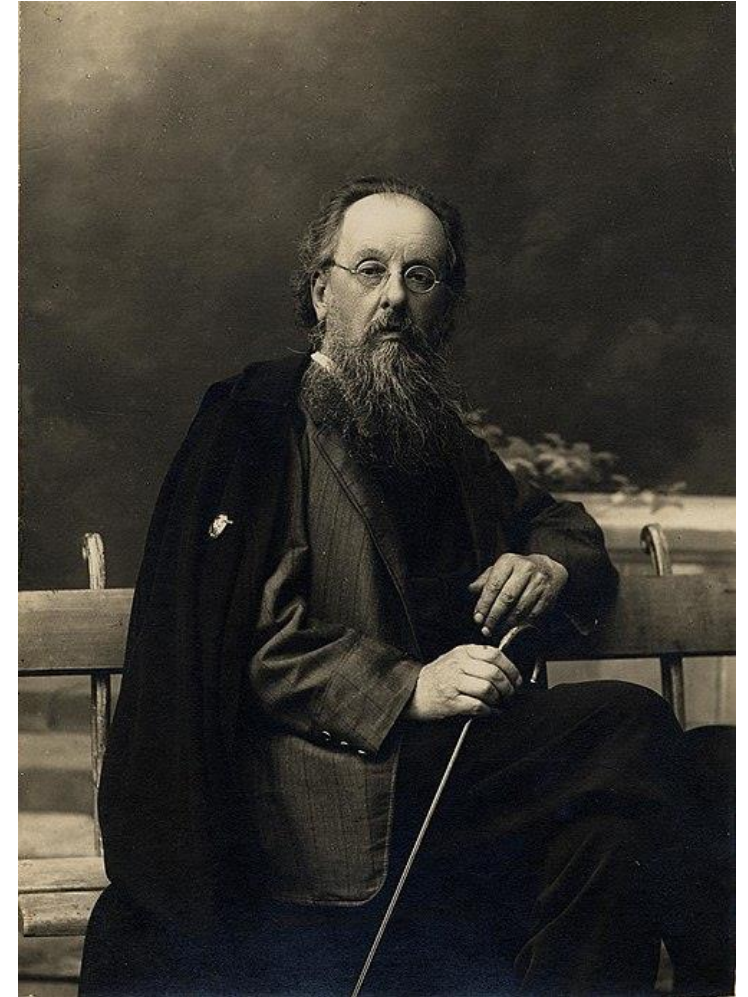
$$F = G \frac{m_1 m_2}{r^2}$$

- Leads to elliptical orbits (explains Kepler's laws)
- In Book 3 (*The System of the World*) of *Mathematical Principles of Natural Philosophy* ("Principia"), Newton made a thought experiment of shooting a cannonball from a great height:
  - Curve down to Earth: <17,700 mph
  - Orbit, i.e., an artificial satellite: 17,700-25,000 mph
  - Escape from Earth's gravitational pull: >25,000 mph



# Konstantin Tsiolkovsky (1857-1935)

- “Founding father” of modern rocketry and astronautics
- Deaf from age 10; self-taught
- Inspired by Jules Verne (1865 *Earth to Moon*)
- 90 published works on space travel and related subjects
- Designs for rockets with steering thrusters, multistage boosters, space stations, and closed-cycle biological systems to provide food and oxygen for space colonies
- Tsiolkovsky rocket equation:  $\Delta v = v_e \ln \frac{m_0}{m_f}$
- 1903, *Exploration of Outer Space by Means of Rocket Devices*



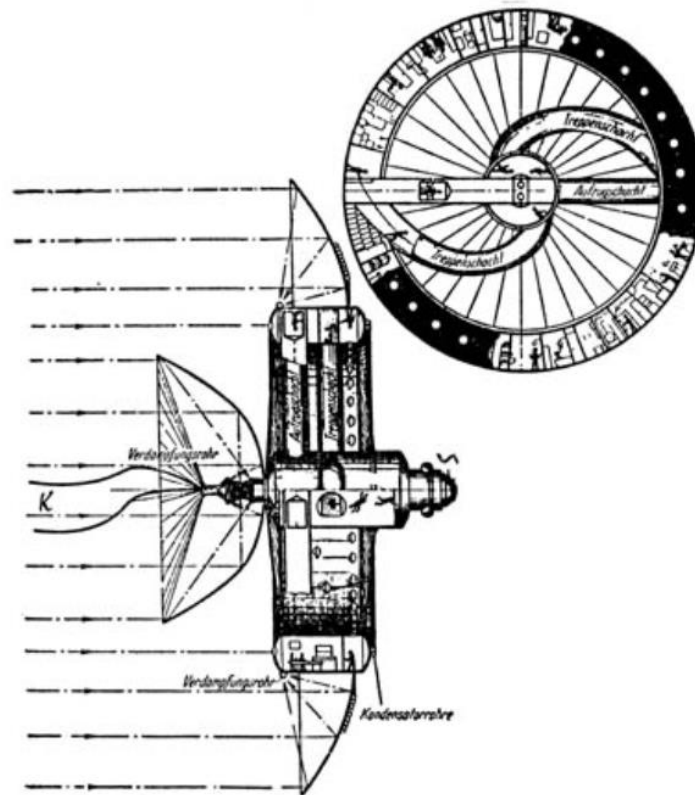
# Herman Oberth (1894-1989)

- Austro-Hungarian-born German physicist and rocket pioneer
- Model rockets starting at age 14; idea of multistage rockets
- 1922 Rocket Science dissertation rejected at U. of Göttingen, but accepted at U. of Cluj (Romania)
- 1923 *The Rocket to the Planetary Spaces*: “Such a station could serve as a basis for Earth observations, as a weather forecasting satellite, as a communications satellite, and as a refueling station for extraterrestrial vehicles launched from orbit.”
- 1928-29: scientific advisor for the Fritz Lang film "Frau im Mond"
- 1941-43 worked on V2 at Peenemünde under Werner von Braun
- 1943-45 transferred to Reinsdorf to work on a solid fuel anti-aircraft missile suggested by him
- 1953 published *Man into Space*
- 1961-62 consultant for the Atlas missile



# Herman Noordung (1892-1929)

- Pseudonym of Herman Potocnik
- Austrian army officer and engineer
- Encouraged by Hermann Oberth, wrote *The Problem of Space Travel: The Rocket Motor* in 1928



# Wernher von Braun (1912-1977)

- Born in Germany, member of the Nazi party and the SS
- 1934 U. Berlin doctorate in physics (aerospace engineering) with a thesis titled "About Combustion Tests."
- Co-developed the V2 rocket (first man-made object in space)
- Worked to end up with U.S. vs. U.S.S.R. as the war's end neared
- Operation Paperclip: 1600 German scientists moved to the U.S.
- Worked on ballistic missiles and the rocket that launched *Explorer*
- 1960's: Director of Marshall Space Flight Center and chief architect of *Saturn V* rocket
- 1970: Deputy Associate Administrator for Planning for NASA
- Developed the idea of Space Camp

# von Braun and Disney

- Von Braun proposed Earth-orbit rendezvous profile for moon missions
- Three *Tomorrowland* Disney specials: *Man in Space (1955)*, ***Man and the Moon (1955)***, *Mars and Beyond (1957)* [8:45]

[YouTube \*Man and the Moon\* from Lucas Dziatkowski](#)

# Science Fiction

- 1869: Edward Everett Hale's *The Brick Moon* has a sphere of bricks 61 meters across accidentally launched into orbit around the Earth with people still onboard
- 1949: *The Conquest of Space* by Willy Ley is a “speculative science” book with illustrations by Chesley Bonestell



# Children's Books

*The Big Book of Space* by Earl Oliver Hurst, Grosset & Dunlap (1959)





# Science Fiction

- Arthur C. Clarke's 1952 *Islands in the Sky*: 16y/o Roy Malcolm wins a trip to Inner Station



- Robert Heinlein's 1953 *Project Moonbase*
  - B&W film set in 1970 has a ship sent from a space station to scout the moon for landing sites for the U.S.

[YouTube Shout Studios](#)

# Science Fiction

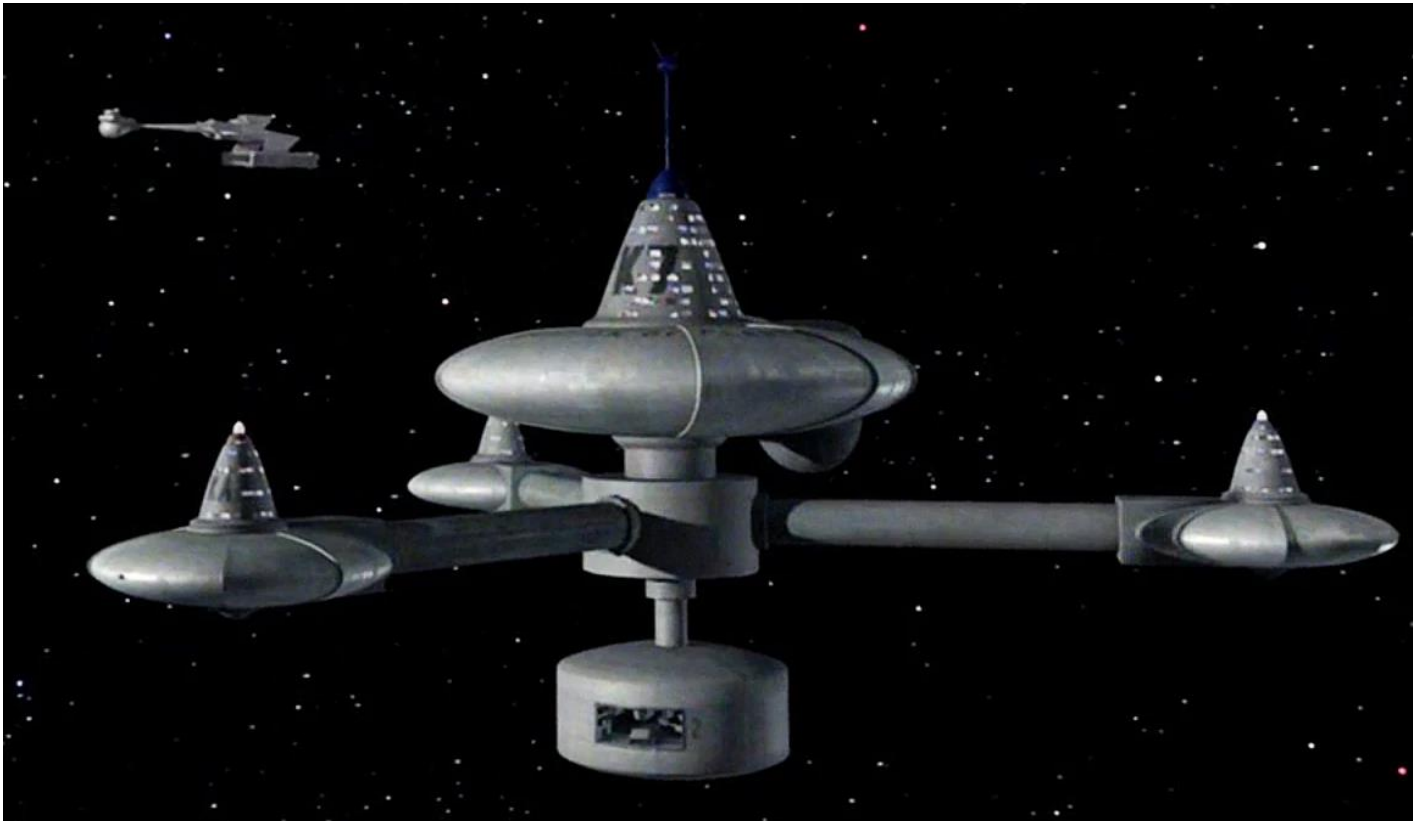
- *Conquest of Space* (1955): First flight to Mars is launched from "The Wheel", mankind's first space station [1:52]

[YouTube Movies and TV \(\\$3.79\)](#)

**Break**

# Science Fiction

- 1967 *The Trouble with Tribbles*: Deep Space Station K-7



# Science Fiction

- 1968 *2001 A Space Odyssey*: Space Station V [6:25]

[\\$3.99 on Amazon](#)

# Science Fiction

- 1969 *Cloud Minders*: Floating city of Stratos



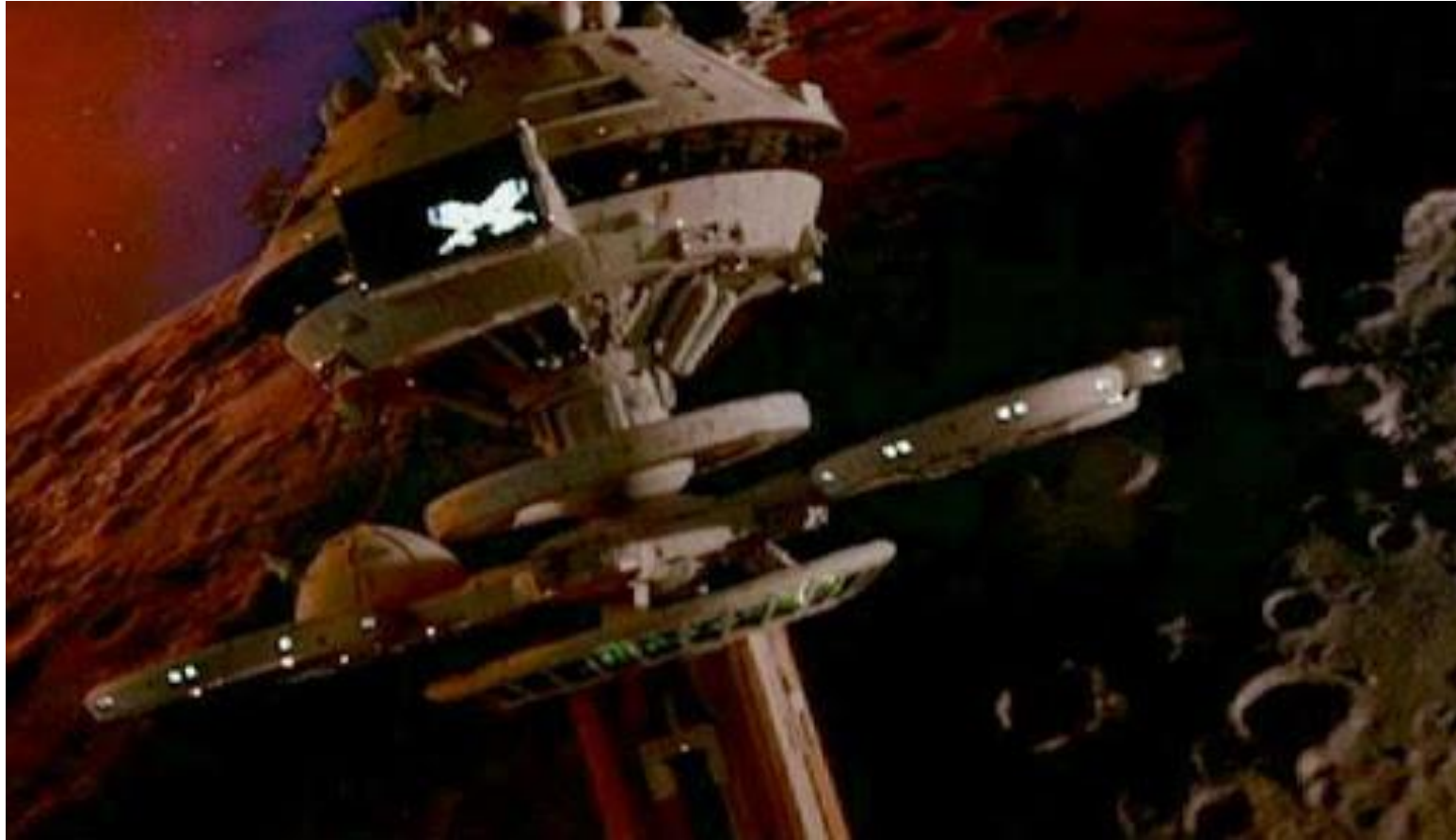
# Science Fiction

- 1977 *Star Wars*: Death Star



# Science Fiction

- 1982 *The Wrath of Kahn*: Regula 1





# Science Fiction

- 1993-1999 *Deep Space Nine* with Commander Sisko



# Science Fiction

Your favorite space station?

# Early Space Travel Timeline

- 1957: Soviets launch Sputnik
- 1958: NASA is created; first space stations planned
- 1960: Douglas Aircraft proposes “wet stage” idea
- April 1961: Yuri Gagarin in Vostok 1 did one orbit in 108 minutes (parachute)
- May 1961-May 1963: 6 manned Mercury flights
- 1963-1969: USAF Manned Orbiting Laboratory
- 1964 James Webb “Future Programs Task Force” → “Apollo Applications Program”
- October 1964: Voskhod 1 launches 3 cosmonauts (first multiple)

# Some Key Milestones Needed for a Space Station

- EVA
- Rendezvous and docking
- Crew transfer

# Voskhod 2: First Space Walk (March 1965)

- Commander Pavel Belyayev and pilot Alexei Leonov
- Required inflatable airlock because avionics used vacuum tubes that could not be exposed to space, and weight limitations prevented carrying tanks with gas to replace the ship's atmosphere
- EVA backpack for oxygen and cooling, on a 17-foot tether
- During 12 minutes of EVA, pressure in the suit limited movement preventing activation of Leonov's suit camera, but the external camera was recovered
- Had a suicide pill in case he couldn't get back inside
- Had to greatly reduce suit pressure to close the airlock
- Temperature rose to 102 °F and had sweat to his knees
- Landed 250 miles away in a dense forest preventing helicopter recovery

# Voskhod 2: First Space Walk (March 1965) [2:39]

[YouTube “The Red Stuff” from CharlieNya \(47:00\)](#)

# First docking: Gemini 8/Agna (March 1966) [4:10]

- March 1965-November 1966: 10 manned Gemini flights

[YouTube Gemini VIII from Retro Space](#)

# First crew transfer: Soyuz 4/5 (January 1969) [4:35]

[YouTube Soyuz 4 & 5 from Scott Manley](#)



# First closed crew transfer: Apollo 9 (March 1969) [2:44]

[YouTube Apollo 9 from Retro Space](#)

# Summary

**Questions and Comments?**