You Are a Rocket Scientist!
What we will do

- Design a rocket with a payload
- Figure out the cost
- Test your design!
How we will do it

• Calculate the mass of the payload
• Pick a rocket engine
• Calculate the mass of the rocket
• Calculate the cost of the rocket
• Test your rocket in a simulation
• Types of spacecraft
  – Manned
  – Scientific
  – Weather
  – Scientific
Costs

• Payload cost
  – Manned spacecraft: 1,000 kg/person and cost is $100,000 x mass of the payload
  – Weather satellite: payload is 300 kg and the cost is $20,000 x mass of the payload
  – Scientific satellite: payload is 500 kg and the cost is $50,000 x mass of the payload
  – Direc TV satellite: payload is 1,000 kg and the cost is $10,000 x mass of the payload

• Rocket engine cost
  – Hydrogen/Oxygen engine cost = $10,000 x mass of the payload
  – Kerosene engine cost = $2,000 x mass of the payload
  – Solid rocket engine = $1,000 x mass of the payload

• Fuel cost
  – Hydrogen/Oxygen fuel cost = $10 x mass of the fuel
  – Kerosene fuel cost = $2 x mass of the fuel
  – Solid rocket fuel cost = $1 x mass of the fuel
The Rocket Equation

- This is the equation you need to know to be a rocket scientist!

\[ m_f = m_p \left( e^{\Delta V/u_e} - 1 \right) \]

- \( e \) is a special number equal to 2.718281828459046...
- The ... means it has an infinite number of digits!
- \( e^x \) means take \( e \) to the \( x \)th power like \( 10^2 = 10 \times 10 = 100 \)
- \( u_e \) is the exhaust velocity - depends on the rocket engine
- \( \Delta V \) is the change in velocity to get you into orbit 10 km/sec!!!!!!
Chart for Calculating

Exponential for the Rocket Equation

Exponential

Solid

Kerosene

Hydrogen

Oxygen

Exhaust velocity (m/s)

2800 3000 3200 3400 3600 3800 4000 4200 4400 4600
An Example

• 2 Person Spacecraft
  – mass payload = 2 x 1,000 = 2,000 kg
  – cost of payload = 2,000 x $100,000 = $200,000,000
  – pick the hydrogen/oxygen engine
  – get the value for “e” from the chart - 9.5
  – mass of the fuel = 2,000 x (9.5 - 1) = 17,000 kg
  – cost of the engine = 2,000 x $10,000 = $20,000,000
  – cost of the fuel = 17,000 x $10 = $170,000
  – total vehicle cost = $200,000,000 + $20,000,000 + $170,000 = $220,170,000