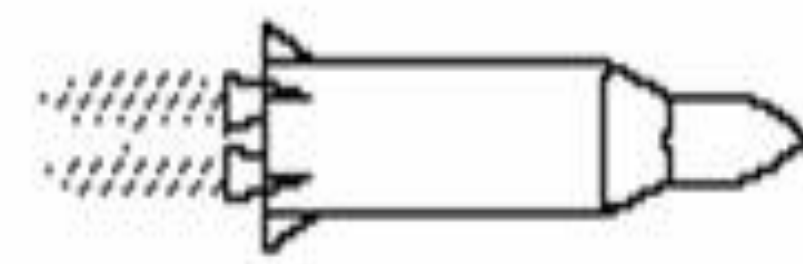


SpaceX Falcon Heavy Physics of Thrust

Isaiah Kang, Colorado College



Momentum and Newton's second law



without gravity

$$F_{ext} = \frac{d(mv)}{dt} = m \frac{dv}{dt} + v_{ex} \frac{dm}{dt} = 0$$

$$\Rightarrow ma = -v_{ex} \frac{dm}{dt} \quad (v_{ex} = \text{exhaust velocity})$$

$$\text{Thrust} = m \frac{dv}{dt} = \left| v_{ex} \frac{dm}{dt} \right|$$

$$\int_{v_i}^{v_f} dv = -v_{ex} \cdot \int_{m_i}^{m_f} \frac{dm}{m}$$

$$v_f - v_i = v_{ex} \cdot \ln \left(\frac{m_i}{m_f} \right)$$



with gravity

$$F_{ext} = \frac{d(mv)}{dt} = m \frac{dv}{dt} + v \frac{dm}{dt} = -mg$$

$$m \frac{dv}{dt} = -v_{ex} \frac{dm}{dt} - mg$$

$$dv = -v_{ex} \frac{dm}{m} - g \cdot dt$$

$$\int_{v_i}^{v_f} dv = -v_{ex} \cdot \int_{m_i}^{m_f} \frac{dm}{m} - \int_{t_i}^{t_f} g \cdot dt$$

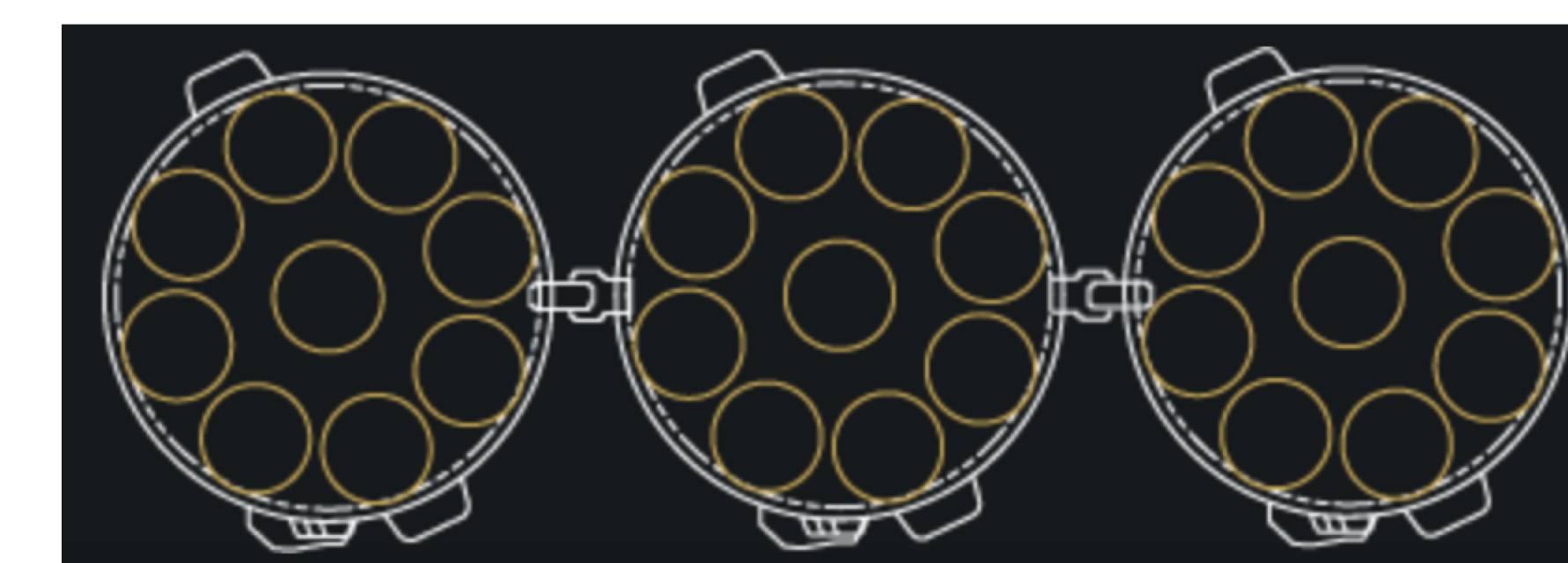
$$v_f - v_i = v_{ex} \cdot \ln \left(\frac{m_i}{m_f} \right) - gt$$

How does it land?



Gridfins help guide the rocket to successfully land vertically.

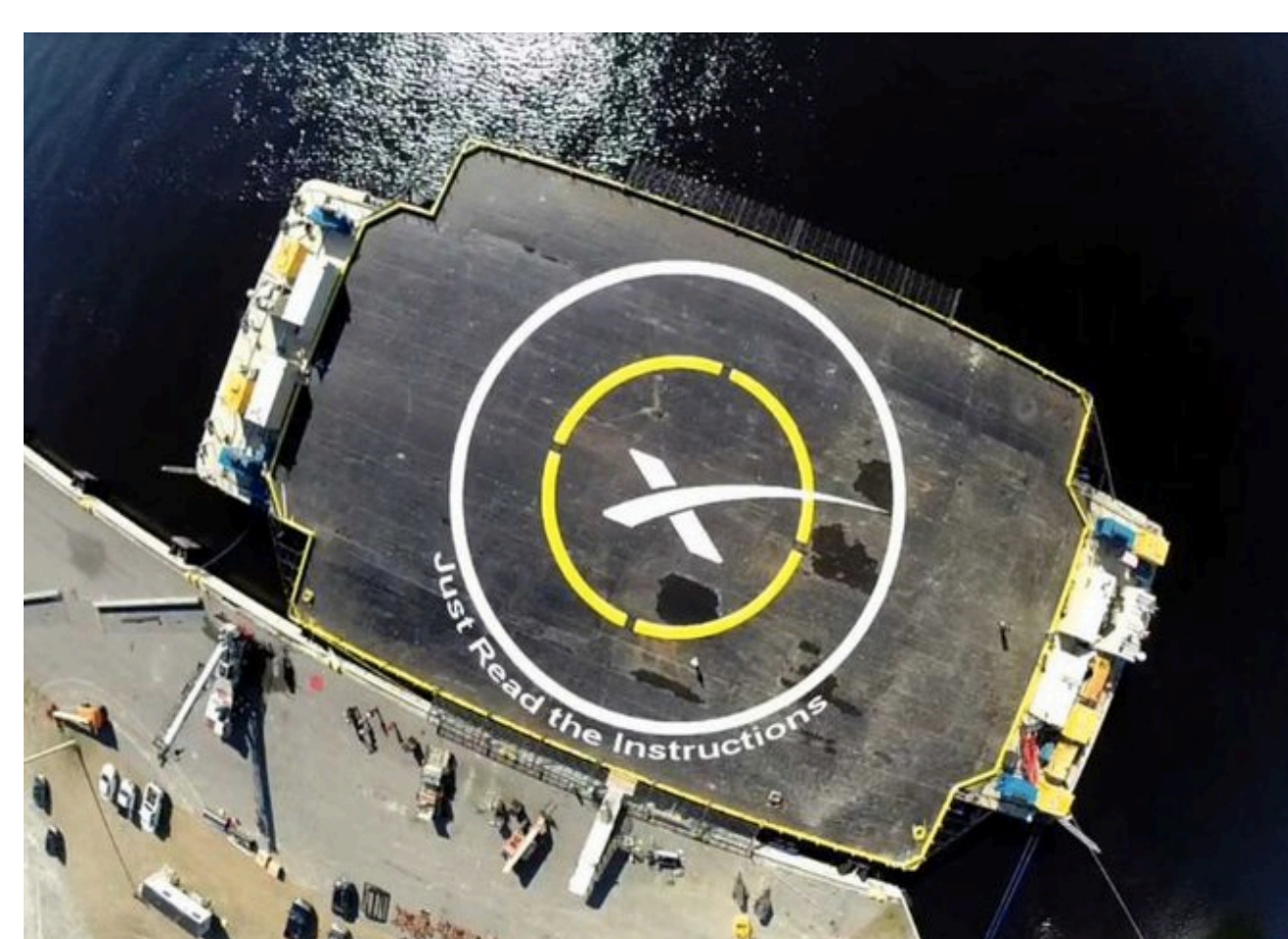
Nitrogen thrusters also help guide the rocket in the vacuum of space.



These 27 merlin engines are the art of Falcon Heavy's launching power. It has about 5M lbs of thrust in total.

Acknowledgments

spaceX.com
Colorado College Physics Department
Youtube.com/everydayastronaut.



Ocean drone ship takes stage one and two rockets back to land.



Elon Musk, the CEO of spaceX, a pioneer of affordable space traveling.

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