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Topics: Rocket Science NOTES FOR THE LECTURER

15/07/2020

Valuable sources of information

European Space Agency: https://www.esa.int/Education/The_rocket_principal

NASA: https://www.grc.nasa.gov/www/k-12/rocket/TRCRocket/rocket_principles.html

Tyranny of the rocket equation: <u>https://www.nasa.gov/mission_pages/station/expeditions/expedition30/tryanny.html</u>

Everyday Astronaut on rocket engines: <u>https://www.youtube.com/watch?v=LbH1ZDImaI8&list=PLWzKfs3icbT6yhDTpO1GyDIz9AXdWSiGr&index=2</u>

More websites and recources are provided along the power point presentation in the comments section









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Topic: Rocket Science

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Workshop structure

1) Why space?

2) Basic principles

3) Rocket engines

4) Do you want to do rocket science?



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400

Picture source

covery

1) Why space? Satellites

- Television
- Telephones and internet
- Navigation
- Weather forecast
- Climate & environmental monitoring
- Space science

(eit) Manufacturing

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Picture source:

1.) Why space? Selfie from the red planet

Finds Evidence of Persistent Liquid Water in the Past Confirms a Suitable Home for Life Organic Carbon Found in Mars Rocks Present and Active Methane in Mars' Atmosphere Radiation Could Pose Health Risks for Humans A Thicker Atmosphere and More Water in Mars' Past



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Picture source:

YML

1.) Why space? Space architecture and colonization

 Marsha is a 3D printed vertical habitat for humans on another planet

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Picture source:

2) Basic principles Forces acting on a rocket Forces During launch After thrust has finished thrust The rocket needs to overcome the gravitational force of its weight and the aerodynamical drag resultant force = thrust - (drag + weight) The resultant force is sum of all • the forces acting on an object drag resultant force drag = drag + weight weight weight Rocket travels upwards. Momentum keeps rocket moving upwards. Speed becomes faster and faster. Speed decreases.



Picture source: <u>here</u>

2) Basic principles Orbit

- Once the rocket reaches the orbit it needs to be moving at orbital velocity
- Otherwise it would fall back to the Earth
- The thrusters are deployed in several stages in order to save mass in the higher altitudes



:YML



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Picture source: <u>here</u>

2) Basic principles Newton's 3rd law

- Newtons 3rd law enables sending objects to space
- Rockets are pushing hot gas at high velocities just like balloons are blowing air which moves them forward

ACTION	
Balloon goes up (Reaction)	
Air goes down (Action)	

YML

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Picture source: <u>here</u>, <u>here</u>

2) Basic principles Conservation of momentum

- The basic concept of conservation of momentum allows us to derive the famous ROCKET EQUATION
- The terminal velocity is dependent on the exhaust velocity from the rocket nozzle and on the initial mass of the rocket including the fuel

$$v(t) = v_0 + v_e \ln \frac{M_0}{M(t)}$$







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Picture source: <u>here</u>

2) Basic principles Means of transportation

- Energy density of fuel options dictates how much payload we can get from the surface of the Earth
- Our daily commute is considerably more efficient than any rocket launch ^(C)

	Percent Propellant	Percent Poyload
Queen Mary my Rickup Locomotive	э 4 7	30-60 } Surfac
fighter Jet Cargo Jet	30 40	20-40 } air
Rocket	85	2 } Space
Molotov Cocktail	54	> Explosi

Rocket 8	quation	Results for Earth Orbit
Propellant	Mass Percen	t Propellant
solid rocket kerosene-O2 Hypergols Hydrogen-O2	96 94 93 83	Percent PayLoad
Saturn V Shuttle Soyuz	85 85 91	4 1 2





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Picture source: <u>here</u>



3.) Rocket Engines

- Fuel and Oxidizer are pumped to the combustion chamber at the highest rate possible
- They react together and expand rapidly towards the nozzle
- The tremendous flow of hot gas is accelerated in the throat





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Picture source: here



3) Rocket Engines

Manufacturing



Picture source: <u>here</u>, <u>here</u>, <u>here</u>







Figure V-4 – Operation of the Turbopump

Video source: <u>here</u>

4) Do you want to do Rocket Science?

There is a great number of space agencies and private companies working in this field

Picture source: here, here



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