Jet propulsion

Jet Propulsion Made by- Bhawesh Lesson Objectives ï‚› After to: ï‚› ï‚› ï‚› ï‚› ï‚› this lesson students should be able Define what a jet engine is Describe how Newton’s laws apply to jet or rocket engines List examples of jet engine applications List some key points in the history of jet propulsion List advantages and disadvantages of jet engines Definition of a Jet Engine ï‚› An engine that burns fuel and uses the expanding exhaust gases to turn a turbine and/or produce thrust ï‚› The concept of thrust is based on the principle of Newton’s Third Law Newton’s Third Law ï‚› For every action there is an equal and opposite reaction ï‚› An example of this is a spray nozzle on a garden hose Newton’s Second Law F= M x A ï‚› Newton’s second law states - The force of an object is equal to its mass times its acceleration ï‚› The force of the spray nozzle is equal to the mass of the water multiplied by the acceleration of the water when it comes through the nozzle ï‚› This is the same principle used in rocket and jet engines Newton in Practice Schematic of a rocket engine Drawing Courtesy of Understanding Flight Where are jet engines used? Commercial Airliners — Boeing 757 Where are jet engines used? Business and personal jets - Learjet Where are jet engines used? Military Bombers B-52 “ Stratofortress" B-2 “ Spirit" Photo Courtesy of www. af. mil Where are jet engines used? Military Fighters F-15 “ EAGLE" F-22 “ Raptor" Photo Courtesy of www. af. mil Where are jet engines used? Helicopters - Apache Photo Courtesy of www. army. mil Where are jet engines used? M-1 Abrams Tank Photo Courtesy of www. army. mil Where are jet engines used? Tractor Pulling Photo Courtesy of gasturbine. pwp. blueyonder. co. uk Where are jet engines used? Speed boats Photo Courtesy of gas-turbines. com History of Jet Engines ï‚› Invented in the 1930’s ï‚› Co-invented by Dr. Hans von Ohain (German) and Sir Frank Whittle (British) ï‚›

Developed their ideas separately and at the time knew nothing of the other’s work History of Jet Engines ï,› Germans were the first to utilize the jet engine as a military tool ï,› The jet powered ME-262 was the first jet powered airplane to see combat ï,› It had a top speed of 540 mph Photo Courtesy of Stormbirds. com History of Jet Engines ï,› The SR-71 “ Blackbird" set the current speed and altitude record for a jet powered aircraft in 1961 ï,› Its top speed is still classified but is in excess of 2, 200 mph Photo Courtesy of NASA Advantages of Jet Engines ï,› High power to weight ratio ï,› No reciprocating parts ï,› ï,› Less parasitic power loss — no need to constantly accelerate and decelerate pistons Less required maintenance Disadvantages of Jet Engines ï,› The high speeds and high operating temperatures make designing and manufacturing gas turbines complex from both the engineering and materials standpoint ï,› These complexities lead to a higher price ï,› Jet engines do not produce high torque levels, which is why they aren’t used in automobiles Review Questions ï,› ï,› ï,› ï,› ï,› Describe how a rocket or jet engine produces thrust How do Newton’s laws relate to jet engine operation Give some examples of jet engine applications When and where were jet engines developed What are some advantages of jet engines What are some disadvantages of jet engines Types of Jet Engines Lesson Objectives ï,› After to: ï,› ï,› ï,› this lesson students should be able List the six different types of jet engines Describe how each type of engine propels the vehicle it is used in List advantages and disadvantages of each type Six different types of jet engines ï,› Turbojet ï,› Turbofan ï,› Turboshaft ï,› Turboprop ï,› Pulsejet ï,› Ramjet X-15 with ramjet engine Photo Courtesy of NASA Turbojet Engine ï,› Thrust produced by gasses expelled from the exhaust nozzle ï,› Very noisy ï,› Used on high speed aircraft due to its small size Drawing Courtesy of

Understanding Flight Turbofan ï‚› Some of the thrust is produced by gasses expelled from the exhaust nozzle just like a turbojet engine ï‚› Most of the thrust is produced from the large inlet fan ï‚› The Bypass ratio of a turbofan is typically 8: 1 (eight times more air is bypassed than passes through the compressor and combustion chamber) Drawing Courtesy of Understanding Flight Turbofan Cont' ï‚› If one wanted to increase thrust you would either have to increase the speed of the air being moved or increase the mass of the air being moved (Thrust = Mass x Acceleration) ... However… ï‚› It is more efficient to accelerate a larger mass of air to a lower velocity ï‚› Due to this principle the turbofan is more efficient than the turbojet ï‚› Due to the lower velocity the turbofan is also significantly quieter than a turbojet ï‚› Almost all modern commercial aircraft use turbofan engines (excluding the Concord) Turbofan Cont' Turboshaft ï‚› Exhaust gas is used to turn turbine shaft which is then used to propel the vehicle ï‚› Exhausted gas produces little thrust because most of the energy is used up by the turbine Drawing Courtesy of www. aircraftenginedesign. com Turboshaft Cont' ï‚› Because of the high speed (RPM) of a turboshaft engine gear reduction must be used to obtain a usable shaft speed — much like the transmission in your car ï‚› This gear reduction also produces torque multiplication Drawing Courtesy of www. aircraftenginedesign. com Turboprop ï‚›A turboprop is essentially a turboshaft engine that is attached to a propeller ï‚› A propeller is more efficient at low speeds than a turbofan or turbojet Drawing Courtesy of www. aircraftenginedesign. com Pulsejet ï‚› Doesn't Use a compressor or turbine ï‚› Doesn't have the ability to produce thrust at low speed (500 mph) Supercharged or Turbocharged Piston Engine ï‚› Able to operate at higher altitudes than a naturally aspirated engine ï‚› Turbocharging or

Supercharging increases the density of the air entering the engine (the engine thinks it is at a lower altitude) ï¿¬Still somewhat limited by altitude ï¿¬Speed is still limited due to propeller inefficiencies at high speeds (> 500 mph) Turbojet ï‚› No reciprocating parts ï‚› Thrust is not greatly affected by altitude ï‚› Relatively small frontal area is desirable for high speed (supersonic) use ï‚› Relatively high-speed, low-mass of exhaust gasses make the turbojet somewhat inefficient ï‚› High speed exhaust is extremely noisy Turbofan ï‚› Because the large inlet fan moves a larger volume of air at a lower velocity, the turbofan is more efficient that the turbojet ï‚› Because of the lower exhaust speeds the noise level is greatly reduced ï‚› The large inlet fan creates a large frontal area which negatively affects drag at high speeds (especially supersonic) ï‚› Most effective at speeds below supersonic (Mach . 5 — Mach . 9) ï‚› However modern fighters are now using state of the art turbofans for supersonic flight Turboprop ï‚› Propellers are most efficient at low speeds ï‚› Produce greater power than a comparable piston engine with less weight, noise, and maintenance ï‚› More expensive than a piston engine ï‚› Must use a gearbox to reduce the high turboshaft rpm’s down to prop rpm’s Turboshaft ï‚› Used in turboprop, helicopter, and land based applications ï‚› Must use a gearbox to reduce rpm’s ï‚› M-1 Abrams tank — 1500 hp turboshaft engine Pulsejet ï‚› Relatively inexpensive ï‚› Doesn’t have the ability to produce thrust at low speeds ï‚› Simple construction Ramjet ï‚› Only used in extremely high speed applications (mostly military / NASA) ï‚› Only produces thrust at high speeds SR-71 ï‚› No moving parts X-15 Review Questions ï‚› Which types of engines are least practical at high rpms? ï‚› Which types of engines are least practical at supersonic speeds? ï‚› Which type of engine could be used to power an electrical generator? ï‚› Why is a

turbofan more efficient than a turbojet engine? References ï,› ï,› Books ï,› V Ganeshan (Mc Graw Hill)-Third Edition ï,› Understanding Flight by David Andreson and Scott Eberhardt Websites ï,› How Stuff Works — www. howstuffworks. com ï,› NASA — www. grc. nasa. com ï,› Factors Affecting Fuel Consumption http://www. jal-foundation. or. jp/ ï,› US Army — www. army. mil ï,› Pratt and Whitney — www. pwc. com ï,› US Air Force — www. af. mil