
GS Foundation Program 2024 | D10 | Benchmark Assignment #111

Subjective Questions:

Q.1) Elucidate the Ramjet and Scramjet engine technology and their significance.

(15 marks, 250 words)

Objective Questions:

Q.1) With reference to the Hypersonic Technology Demonstrator Vehicle (HSTDV), consider the following statements:

1. It uses indigenously developed scramjet propulsion system.
2. It can be used for long-range cruise missiles as well as for launching satellites.

Which of the statements given above is/are correct?

- a) 1 only
- b) 2 only
- c) Both 1 and 2
- d) Neither 1 nor 2

Q.2) With reference to the Solid Fuel Ducted Ramjet (SFDR) Technology, consider the following:

1. It is a missile propulsion system based on solid fuelled air-breathing ramjet engine.
2. It is useful to develop long range air-to-air missiles.

Which of the statements given above is/are correct?

- a) 1 only
- b) 2 only
- c) Both 1 and 2
- d) Neither 1 nor 2

Q.3) With reference to Defense System of India, consider the following statements:

1. Ballistic missiles are powered initially by a rocket or series of rockets in stages.
2. Unlike Cruise missiles, ballistic missiles can carry nuclear warheads.
3. S-400 is an anti-missile defence system which can engage both cruise missiles and ballistic missiles.

Which of the statements above is/are correct?

- a) 1 and 2 only
- b) 2 and 3 only
- c) 1 and 3 only
- d) 1, 2 and 3

Q.4) A ramjet is a variant of jet engine that are used in space missions. What is its significance?

1. They work most efficiently at hypersonic speeds.
2. They are mostly employed for movement in vacuum conditions.
3. They can quickly move an aircraft from standstill to very high acceleration.

Select the correct answer using the code given below:

- a) 1 and 3 only
- b) 2 and 3 only
- c) 1 only
- d) None of the Above

Q.5) Which of the following are the areas of potential application of air-breathing scramjet technology?

1. Hypersonic missiles
2. Air transportation
3. Satellite Launch

Select the correct answer using the codes given below.

- a) 1 and 2 only
- b) 1 and 3 only
- c) 3 only
- d) 1, 2, and 3

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Subjective Questions:

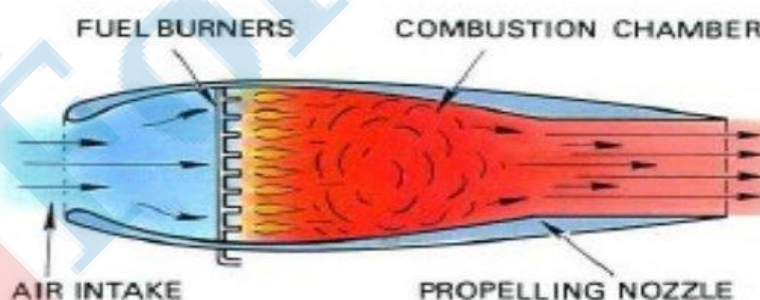
Q.1) Elucidate the Ramjet and Scramjet engine technology and their significance.

Ramjet and Scramjet are the air-breathing rocket systems which use the atmospheric oxygen from their surroundings and burn it with the stored onboard fuel. Conventional rocket technology requires to carry liquid oxygen on board to combine with combustible fuel for the rocket to produce thrust and propel the rocket. However, if the need for liquid oxygen is taken away (by producing air-breathing technology), the spacecraft can be much lighter, hence cheaper to launch.

Ramjet:

1. A **ramjet** is a form of air-breathing jet engine that uses the vehicle's forward motion to compress incoming air for combustion without a rotating compressor.
2. Ramjets work most efficiently at supersonic speeds around Mach 3 (three times the speed of sound) and can operate up to speeds of Mach 6. However, the ramjet efficiency starts to drop when the vehicle reaches hypersonic speeds.
3. A dual mode ramjet (DMRJ) is a type of jet engine where a ramjet transforms into scramjet over Mach 4-8 range, which means it can efficiently operate both in subsonic and supersonic combustor modes.

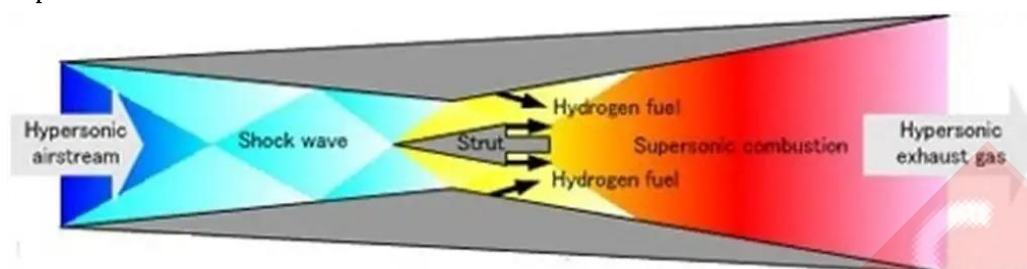
Ram Jet Engine



Scramjet:

1. A **scramjet** engine is an improvement over the ramjet engine as it efficiently operates at hypersonic speeds and allows supersonic combustion. Thus, it is known as Supersonic Combustion Ramjet, or Scramjet.
2. Scramjet engines obtain oxygen from the atmosphere by compressing the incoming air before combustion at hypersonic speed. It uses hydrogen as fuel and the oxygen from the atmospheric air as the oxidizer.

- When the rocket reaches a height of 11 km, the scramjet engines would start breathing air directly from the atmosphere.
- Scramjets are highly inefficient at low speeds. Their efficiency increases at supersonic speeds.



Points of Difference between Ramjet & Scramjet are-

Ramjet	Scramjet
1. It is a type of airbreathing jet engine that generates thrust by using the engine's forward motion.	It is a ramjet airbreathing jet engine version in which combustion occurs in supersonic airflow.
2. Using shock cones, a ramjet slows the air to subsonic speeds before combustion.	A scramjet relies on high vehicle speed to forcefully compress entering air before combustion.

The key benefits of scramjet and ramjet engines are that **they don't have rotating or moving parts, which enables the vehicle to travel at higher speeds with greater efficiency.**

Significance:

- High-Speed Travel:** Ramjet and scramjet technologies hold the potential to revolutionize high-speed travel, enabling rapid transportation across the globe or even suborbital flights.
- Space Launch:** Scramjets, with their ability to operate efficiently at hypersonic speeds, are considered for space launch vehicles. They could significantly reduce the cost of reaching orbit by providing a more fuel-efficient propulsion method.
- Military Applications:** Ramjets and scramjets are integral to the development of hypersonic missiles, offering increased speed and maneuverability, making them challenging for traditional defense systems to intercept.
- Scientific Exploration:** These technologies are essential for scientific research and exploration, facilitating missions to study the Earth's atmosphere, gather data on atmospheric conditions, and conduct experiments in microgravity.

Ramjet and scramjet engines represent cutting-edge technologies with broad applications, from high-speed air travel to space exploration and defense. Their significance lies in their potential to enhance efficiency, reduce costs, and enable new frontiers in transportation and exploration.

Objective Questions:

Q.1) With reference to the Hypersonic Technology Demonstrator Vehicle (HSTDV), consider the following statements:

1. It uses indigenously developed scramjet propulsion system.
2. It can be used for long-range cruise missiles as well as for launching satellites.

Which of the statements given above is/are correct?

- a) 1 only
- b) 2 only
- c) Both 1 and 2
- d) Neither 1 nor 2

Ans) c

Exp) Option c is correct.

Relevance) In September, 2020, the Defence Research and Development Organisation (DRDO) on Monday **successfully flight tested** the Hypersonic Technology Demonstrator Vehicle (HSTDV) – an unmanned scramjet vehicle.

Statement 1 is correct. The Hypersonic Technology Demonstrator Vehicle (**HSTDV**) uses indigenously developed scramjet propulsion system. The **scramjets** are a variant of a category of jet engines called **the air breathing engines**. The ability of engines to handle airflows of speeds in multiples of speed of sound, gives it a capability of operating at those speeds. Hypersonic speeds are those which are five times or more than the speed of sound.

Statement 2 is correct. The indigenous development of HSTDV technology will boost the development of the systems built with hypersonic vehicles at its core, including both offensive and defensive hypersonic **cruise missile systems and also in the space sector.**

Q.2) With reference to the Solid Fuel Ducted Ramjet (SFDR) Technology, consider the following:

1. It is a missile propulsion system based on solid fuelled air-breathing ramjet engine.
2. It is useful to develop long range air-to-air missiles.

Which of the statements given above is/are correct?

- a) 1 only
- b) 2 only
- c) Both 1 and 2
- d) Neither 1 nor 2

Ans) c

Exp) Option c is correct.

Statement 1 is correct. Solid Fuel Ducted Ramjet (SFDR) Technology: SFDR technology is a missile propulsion system based on the concept of Ramjet Engine principle. The system utilizes a solid fuelled air-breathing ramjet engine. Unlike solid-propellant rockets, the Ramjet

takes up oxygen from the atmosphere during flight. Thus, it is light in weight and can carry more fuel.

Statement 2 is correct. Successful demonstration of SFDR technology will enable India to develop indigenous long-range air-to-air missiles. Air-to-air missiles which use SFDR technology can achieve longer ranges as they do not require oxidizers (that take oxygen from atmosphere). The missile based on SFDR fly at supersonic speeds and high maneuverability ensures the target aircraft cannot get away.

Q.3) With reference to Defense System of India, consider the following statements:

1. Ballistic missiles are powered initially by a rocket or series of rockets in stages.
2. Unlike Cruise missiles, ballistic missiles can carry nuclear warheads.
3. S-400 is an anti-missile defence system which can engage both cruise missiles and ballistic missiles.

Which of the statements above is/are correct?

- a) 1 and 2 only
- b) 2 and 3 only
- c) 1 and 3 only
- d) 1, 2 and 3

Ans) c

Exp) Option c is correct.

The Integrated Guided Missile Development Programme (IGMDP) conceived by renowned scientist **Dr. A P J Abdul Kalam** to enable India attain self-sufficiency was **started in 1983** completed in **March 2012**. It was an Indian Ministry of Defence programme for the research and development of the comprehensive range of missiles. India now moved on with the new **Indian Ballistic Missile Defence Program** as an initiative to develop and deploy a multi-layered ballistic missile defence system to protect India from ballistic missile attacks.

Statement 1 is correct. Ballistic missiles are powered by rockets initially but then they follow an unpowered, free-falling trajectory towards their target. While cruise missiles are self-propelled systems till the end of its flight.

Statement 2 is incorrect. Both cruise missiles and Ballistic missiles can carry either nuclear or conventional warheads.

Statement 3 is correct. The **S-400 Triumph air defence system** developed by Almaz Central Design Bureau of **Russia** integrates a multifunction radar, autonomous detection and targeting systems, anti-aircraft missile systems, launchers, and command and control centre. The S-400 missile defence system is equipped with four different missiles which can engage enemy aircraft, **ballistic missiles, cruise missiles** and AWACS planes at **400 km**, 250 km, the medium-range 120 km and the short-range 40 km.

Q.4) A ramjet is a variant of jet engine that are used in space missions. What is its significance?

1. They work most efficiently at hypersonic speeds.
2. They are mostly employed for movement in vacuum conditions.
3. They can quickly move an aircraft from standstill to very high acceleration.

Select the correct answer using the code given below:

- a) 1 and 3 only
- b) 2 and 3 only
- c) 1 only
- d) None of the Above

Ans) d

Exp) Option d is correct.

Statement 1 is incorrect. A ramjet is a form of air-breathing jet engine that uses the vehicle's forward motion to compress incoming air for combustion without a rotating compressor.

Ramjets **work most efficiently at supersonic speeds** around Mach 3 (three times the speed of sound) and can operate up to speeds of Mach 6. However, **the ramjet efficiency starts to drop when the vehicle reaches hypersonic speeds.**

A scramjet engine is an improvement over the ramjet engine as it efficiently operates at hypersonic speeds and allows supersonic combustion. Thus, it is known as Supersonic Combustion Ramjet, or Scramjet.

Statement 2 is incorrect. Ramjets cannot work in vacuum as it is **a form of air-breathing jet engine** that uses the vehicle's forward motion to compress incoming air for combustion without a rotating compressor. Fuel is injected in the combustion chamber where it mixes with the hot compressed air and ignites.

Statement 3 is incorrect. Ramjets cannot produce thrust at zero airspeed; **they cannot move an aircraft from a standstill.** A ramjet-powered vehicle, therefore, **requires an assisted take-off** like a rocket assist to accelerate it to a speed where it begins to produce thrust.

Q.5) Which of the following are the areas of potential application of air-breathing scramjet technology?

1. Hypersonic missiles
2. Air transportation
3. Satellite Launch

Select the correct answer using the codes given below.

- a) 1 and 2 only
- b) 1 and 3 only
- c) 3 only
- d) 1, 2, and 3

Ans) d

Exp) Option d is correct.

Nearly 70% of the propellant (fuel-oxidiser combination) carried by today's launch vehicles consists of oxidiser. In an air-breathing scramjet engine, air from the atmosphere is rammed into the engine's combustion chamber at a supersonic speed of more than Mach two.

Mastering the air-breathing scramjet technology will lead to the development of hypersonic missiles, faster civilian air transportation and facilities for putting satellites into orbit at a low cost.