

Concept - Reflection of light

Content - Reflecting Telescope

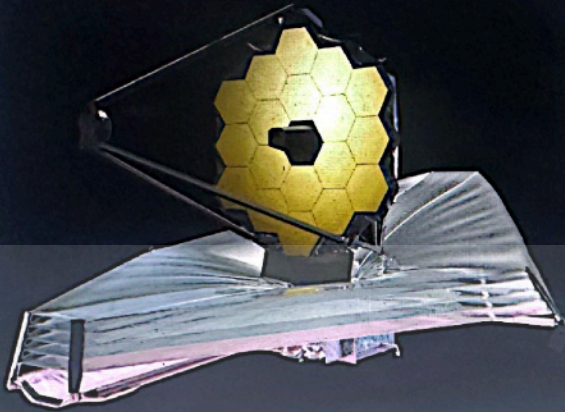
Criteria - D

IB learner's profile - Balance

The below reference is from IB MYP past paper year 2024. Read the below content and answer the questions that follow based on criteria D

The Hubble Space Telescope, named after Edwin Hubble, was built in the 1970s, but wasn't launched until 1990 due to technical delays and budget problems. Soon after the telescope had been successfully launched into space, a problem with the main mirror of the telescope was discovered. A mission in 1993 corrected the problem with the mirror and brought instrument upgrades to the telescope. The mission to correct the telescope took almost 11 days and the crew members made five spacewalks during the mission. The Hubble Space Telescope changed our understanding of the universe forever. A famous image was taken in 1995 of the Eagle Nebula at a distance of around 7000 light years from Earth. The image showed dust and gas in the process of creating new stars. This image has been replicated on everything from T-shirts to coffee mugs. Plans for a new space telescope started in 1996. The new telescope would include a larger mirror and would have to travel further from Earth so that it could see deeper into space than ever before. This telescope, named the James Webb Space Telescope, was designed to look for waves in the infrared region of the electromagnetic spectrum. The telescope would be sent to a location that was so far from Earth that it couldn't be repaired if there were problems. The telescope is the most expensive piece of scientific equipment ever made. However, the 10-billion-dollar cost is much less than the over 750 billion dollars that the US has as its annual military budget.

James Webb Space Telescope (JWST)



Fact file for JWST

Initial budget US\$1 billion

Mirror is 6.5 m diameter compared to 2.4 m in Hubble

18 hexagonal sections to allow the mirror to be folded for transport

Final cost US\$10 billion

Launched December 2021

First images released July 2022

Question 1 - 13 marks

Using the information and your wider MY studies, discuss and evaluate the development of the JWST and its role in extending our knowledge and understanding of the universe. In your answer, you should include:

- the scientific challenges of launching a telescope into space
- the social or cultural implications of the observations made with telescopes
- the economic implications of spending government funds on a space telescope
- a concluding appraisal giving your opinion on the impact of the JWST.

Reference -

The JWST carries a mid-infrared instrument that some people believe could provide evidence of life on other planets.

Some facts about the JWST are given below.

- The instrument dioxide on planets can detect substances such as water, oxygen, ozone, methane and carbon outside our solar system. These planets are known as exoplanets.
- The exoplanet has to be orbiting a specific kind of star, known as a white dwarf, for the substances to be detected by the instrument.

•The nearest white dwarf star to Earth is over eight light-years away and there are only about 34 known white dwarf stars within 40 light-years of Earth..

Question 2 - 6 marks

Use the information above to evaluate the benefits and limitations of using the mid-infrared instrument on the JWST to search for evidence of life on other planets.

Marking scheme

Question 1

The scientific challenges of launching a telescope into space		
Mark	Descriptor	Notes
1	A statement	The main themes to explore are: <ol style="list-style-type: none"> 1. Requires great technological innovations, extensive testing to ensure it can work remotely 2. Issues due to location / distance from Earth, including communication issues and the danger of impact with other objects in space 3. Thermal issues 4. Deployment issues, including coordinating the launching process and navigating to the required location
2	A statement with further support <i>or</i> Two statements	Examples of statements <ul style="list-style-type: none"> • repair of space telescopes is challenging • a large diameter mirror requires advanced scientific innovation • harsh conditions in space. Nothing to protect the telescope from extreme high and low temperatures • once in deep space, the telescope must operate autonomously for long periods • the launching process is complex and requires precise calculations and coordination
3	Two statements with further support for one	Examples of scientific support <ul style="list-style-type: none"> • the JWST's remote location at L2 (from video) could not be physically repaired (maintenance) • folding and unfolding mechanisms for 18 hexagonal mirrors would need to be created to fit into the rocket. (OR reference to precision alignment of mirror segments)
4	Two statements with further support for both	<ul style="list-style-type: none"> • metal parts of the telescope can fuse together due to temperatures causing cracks and damage to the telescope • during testing, simulated conditions must include complexities such as vacuums, intense vibrations, extremely loud sounds, dense dust, extreme temperatures • autonomous communication links with earth are difficult to establish since ... the position of the satellite relative to the earth will be changing ... obstacles may block communication lines, time lags of signals due to long distances.

The social or cultural implications of observations made with telescopes		
Mark	Descriptor	Notes
1	A statement	The main themes to explore are <ol style="list-style-type: none"> 1. Expanding human knowledge 2. Religion / philosophical 3. Artistic / literary creativity 4. Collaboration internationally
2	A statement with further support <i>or</i> Two statements	Examples of social or cultural implications <ul style="list-style-type: none"> • it can expand our understanding of the universe • it can improve international collaboration • images observed will contribute to humanity's collective cultural heritage... • artists can draw inspiration from these images to create pieces that depict the mystery and beauty of the universe • observations may go against or support certain religious beliefs or conspiracy theories. • it can stimulate interest in science amongst a new generation of young people
3	Two statements with further support for one	Examples of support <ul style="list-style-type: none"> • by observing the formation of stars and galaxies in closer detail (with infrared sensors), we will be able expand our knowledge of cosmic evolution • space telescopes can involve collaboration between countries (as with the JWST), which would lead to greater unity amongst nations • deep space images have been incorporated in artwork displayed in museums, clothing designs and tattoos • images from space telescopes can be used in church or religious groups to portray the wonders of God or support beliefs that there is extra – terrestrial life

The economic implications of spending government funds on a space telescope		
Mark	Descriptor	Notes
1	A statement	<p>The main themes to explore are</p> <ol style="list-style-type: none"> High costs / budget Economic growth due to tech advancement, industry innovation, or scientific discoveries <p>Examples of economic implication</p> <ul style="list-style-type: none"> a large government investment for a space telescope the development of a space telescope would lead to new tech or industrial innovations helping society <p>Examples of support (do not need to be linked to the JWST directly)</p> <ul style="list-style-type: none"> space telescopes require nations to budget carefully. These funds could be used for other services such as healthcare and education advancement in materials, optics, and other engineering solutions (such as folding mirrors) could lead to other innovations and applications enhancing the economy the budget of the JWST does not seem high when it is placed alongside the annual budget of the US military (750 billion) and this money was spent over the many years of the project countries that develop space telescopes can attract the best and brightest scientists to work for them, some of these scientists will relocate from overseas
2	A statement with further support or Two statements	
3	Two statements with further support for one	
4	Two statements with further support for both	

A concluding appraisal giving your opinion on the impact of the JWST		
Mark	Descriptor	Notes
1	A simple conclusion	<p>Characteristics of a simple conclusion</p> <ul style="list-style-type: none"> the candidate writes a statement saying they are in support/against JWST in simple terms without an attempt to balance the positive and negative aspects which are evident <p>Characteristics of an appraisal</p> <ul style="list-style-type: none"> the candidate recognises the fact that there are positive and negative aspects to the impact of the JWST but makes a case for why they are in support/against the development by weighing up both sides
2	A concluding appraisal with reference to issues raised	

Question 2

<p>Accept any two reasonable benefits, for example [max 2]</p> <ul style="list-style-type: none"> planetary data that was not available previously picks up wavelengths specific to biomolecules <p>Accept any two reasonable limitations, for example [max 2]</p> <ul style="list-style-type: none"> technique is limited in scope – can only be used for planets around small number of stars no direct evidence of existence of alien life cannot be sure if molecules were formed biologically or geologically <p>A simple conclusion</p> <p>Conclusion is linked to benefits and limitations</p>	WTTE	6	D
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