Thank you for subscribing to SmarterScience Teacher Edition in 2024.

Key features of the Engineering “2024 HSC Comprehensive Revision Series” include:

- ~15 hours of cherry-picked HSC revision questions by topic
- Targeted at motivated students aiming for a Band 5 or 6 result
- Weighting toward more difficult examples
- Mark allocations of topic areas reflect their HSC exam allocations
- ***Attempt, carefully review and annotate*** this revision set in Term 3
- This question set provides the foundation of a concise and high-quality revision resource for the run into the HSC exam.

Our analysis on each topic, the common question types, past areas of difficulty and recent HSC trends all combine to create this revision set that ensures students cover a wide cross-section of the key areas.

IMPORTANT: If students have been exposed to questions in these worksheets during the year, we say great. Many top performing students attest to the benefits of doing quality questions 2-3 times before the HSC. This type of revision set is aimed at creating confidence and *speed through the exam*, with cherry picked questions that cover all important elements of revision while avoiding low percentage rabbit hole excursions.

HSC Final Study: Aeronautical Engineering

- Materials (~7.0% historical contribution)

Key Areas addressed by this worksheet

- *Specialist testing* of aircraft materials was last examined in a 2022 multiple-choice question and before that in a more substantial 4-mark question looking at landing gear testing (*2020 HSC 22c*).
- *Metal Alloys* and the change in their properties under different treatments attracted significant mark allocations in the period 2017-2019 which is well covered in the revision set.
- *2019 HSC 25b* and *2019 HSC 24a* both feature and require comparisons between metal alloys and other composites such as carbon fibre.
- Thermosetting polymers have been tested in 2023 and 2021, with *2023 HSC 21d* a "must review" question that produced a state mean mark of just 36%.
- Students must be able to efficiently summarise the manufacturing and in-service benefits of composites such as Kevlar, carbon fibre (*2021 HSC 23d*) and FML. Manufacturing descriptions have caused particular issues and *2017 HSC 22b* and *2016 HSC 25aii* are important revision examples.
- *Corrosion* has been examined 5 times in the last 7 years (most recently 2022). Multiple questions address this subtopic, ranging from high difficulty multiple-choice (*2017 HSC 17 MC*) to 2-3 mark longer response (*2022 HSC 24b, 2021 HSC 23a*).

General study tips:

- *Working past 11 pm inhaling Red Bull, coffee and chocolate = bad*
- *Getting to bed by 10 pm, waking up at 6 am and studying = good*
- *Extra 10% return – add a cold shower to the mix*

ENGINEERING

Stage 6

2024 Comprehensive Revision Series
Aeronautical Engineering
- Materials

Exam Equivalent Time: 45 minutes *(based on allocation of 1.5 minutes per mark)*

Questions

1. ENGINEERING, AE 2022 HSC 17 MC

During routine maintenance, ultrasonic testing is performed on some aircraft components such as aircraft landing gear.

What is the reason for performing this test?

A. It can be performed quickly.

B. It reveals any surface defects.

C. It reveals any hidden internal faults.

D. It can be carried out using simple techniques.

---

2. ENGINEERING, AE 2019 HSC 15 MC

Titanium is used to manufacture aircraft undercarriages that support landing wheels.

Why is titanium used in preference to alloy steel for this purpose?

A. It has lower density and lower strength.

B. It has lower density and higher strength.

C. It has higher density and lower strength.

D. It has higher density and higher strength.

---

3. ENGINEERING, AE 2017 HSC 11 MC

The properties of some aluminium-magnesium-silicon alloys can be altered using the following procedure.

Solution treating → Quenching → Reheating

What type of hardening process is this?

A. Case hardening

B. Flame hardening

C. Induction hardening

D. Precipitation hardening

---

4. ENGINEERING, AE 2020 HSC 16 MC

Which of the following contributes to pitting or crevice corrosion in aircraft component joints?

A. Water levels

B. Alloy concentrations

C. Oxygen concentrations

D. Levels of static electricity

---

5. ENGINEERING, AE 2017 HSC 17 MC

In which of the following does an impervious oxide surface layer provide corrosion resistance for the base metal?

A. Zinc coating of steel in underground applications

B. Carbon fibre panels in automotive body applications

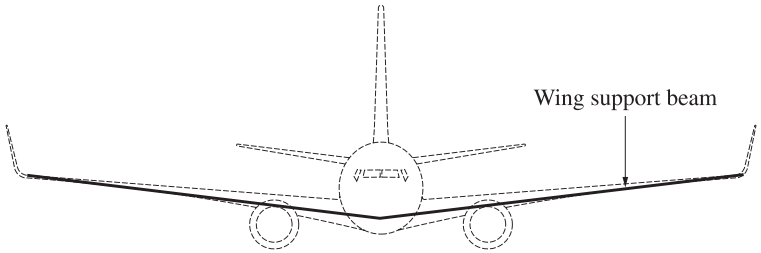
C. Powder coating of steel structures in marine applications

D. Nickel-based alloys in high temperature aeronautical applications

---

6. ENGINEERING, AE 2019 HSC 24a

An image of an aeroplane is shown with the position of the wing support beam indicated.



Assume the engines are supported by the single beam. The beam runs through the plane, wing tip to wing tip.

Compare the use of composite materials with the use of metals for the manufacture of the beam. ***(3 marks)***

7. ENGINEERING, AE 2019 HSC 25b

Some materials have properties that allow them to be used in the manufacture of both modern racing yachts and aircraft. These materials include Kevlar® aramid fibre, carbon fibre epoxy composites and aluminium alloys.

Complete the table by providing a property which makes each of these materials suitable for the manufacture of both yachts and aircraft. ***(3 marks)***

Material	*Property*
Kevlar® aramid fibre	
Carbon fibre epoxy composite	
Aluminium alloy	

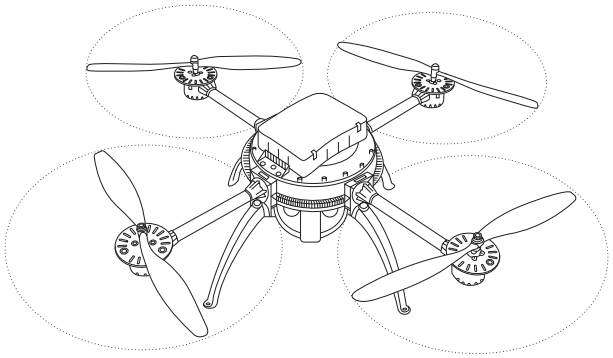
8. ENGINEERING, AE 2020 HSC 22c

A periodic aircraft maintenance inspection is to be carried out.

Identify and justify an appropriate test that could be used to check the airworthiness of the landing gear. ***(4 marks)***

9. ENGINEERING, AE 2016 HSC 25aii

An image of a small drone is shown.



Nylon propellers are used on drones whereas carbon fibre composite propellers are used on commercial aircraft.

Describe a suitable manufacturing method for each type of propeller. ***(3 marks)***

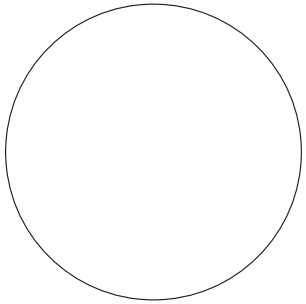
10. ENGINEERING, AE 2022 HSC 24b

The image shows corroded screws on the body of an aircraft.

Identify this type of corrosion and explain how it can occur. ***(3 marks)***

11. ENGINEERING, AE 2023 HSC 21d

Draw, label and describe the microstructure of a thermosetting polymer. ***(3 marks)***



12. ENGINEERING, AE 2023 HSC 25a

Describe the process of compression moulding when used to manufacture aircraft components.
(3 marks)

13. ENGINEERING, AE 2017 HSC 26c

In modern aircraft, the external skin is riveted to the frame using solution treated and quenched aluminium 4% copper alloy rivets. These rivets are used immediately to attach the external skin of the aircraft to the frame.

Describe the changes that occur to the structure and properties of these rivets after installation.
(3 marks)

Worked Solutions

1. ENGINEERING, AE 2022 HSC 17 MC

$\Rightarrow C$

---

2. ENGINEERING, AE 2019 HSC 15 MC

→ Lower density and higher strength, means the material has a very high strength to weight ratio, or specific strength.

→ This is one of the most beneficial characteristics associated with titanium alloys.

$\Rightarrow B$

---

3. ENGINEERING, AE 2017 HSC 11 MC

→ This is the process of precipitation hardening as outlined in the course.

$\Rightarrow D$

Mean mark 55%.

---

4. ENGINEERING, AE 2020 HSC 16 MC

Pit and crevice corrosion occurs when:

→ The anode and cathode are both in contact with an electrolyte, and

→ The concentration is lower at the anode.

→ Therefore, oxygen concentrations contribute as oxygen is an electrolyte which is often in contact with aircraft component joints.

$\Rightarrow C$

Mean mark 54%.

Worked Solutions

5. ENGINEERING, AE 2017 HSC 17 MC

→ B is incorrect as carbon fibre is not a base metal.

→ A and C may form protective layers, however they are the result of a base metal being coated with a different anodic metal.

→ D is the correct answer as Nickel-based alloys form an impervious oxide layer to prevent corrosion without the need to coat them with a different metal.

$\Rightarrow D$

♦♦♦ Mean mark 14%.

---

6. ENGINEERING, AE 2019 HSC 24a

Answers could include 3 of the following comparisons:

Composite materials vs Metals

→ Composite materials are lighter than metals.

→ Manufacture: Carbon fibre epoxy composite beams requires specialised equipment whereas metal based inputs can be manufactured using readily accessible tools such as welders, gas torches and plasma cutters.

→ Composite materials are easier to lift due to lighter weight. This allows workers to position them more easily during the construction process.

→ Equipment used for making carbon fibre epoxy moulds likely to be more accurate than in metal fabrication. However, it is possible to achieve similar accuracy in machining metals compared to that of composite materials.

→ Due to the nature of the wing support beam and the stresses placed on it, a metal beam is subject to stress weaknesses (such as scratches and corners of drilled holes) and flaws in welds that create fatigue. Carbon fibre not affected by fatigue cracking.

---

7. ENGINEERING, AE 2019 HSC 25b

Include one of the properties in the second column:

Material	*Property*
Kevlar® aramid fibre	Tear resistant, high tensile strength, light weight fibre
Carbon fibre epoxy composite	High tensile strength, low weight, stiff composite
Aluminium Alloy	Strength to weight ratio is high and material is tough.

8. ENGINEERING, AE 2020 HSC 22c

Ultrasonic testing:

→ Can determine whether there are internal cracks/flaws within the landing gear.

→ This is appropriate as the equipment is portable, the testing is non-destructive and can be done on site.

Other appropriate tests could include:

Dye penetrant or fluorescent inspection tests

→ Reveals surface cracks/flaws and is non-destructive.

Magnetic particle/eddy current inspection

→ Non-destructive and reveals surface and shallow flaws through discrepancies in electric and magnetic fields.

Visual inspection

→ For any obvious faults/damages/cracks.

Radiography

→ Used to find deep internal flaws, non-destructive.

9. ENGINEERING, AE 2016 HSC 25aii

♦♦ Mean mark 36%.

Nylon propellers

→ Injection moulded

→ A screw feeds nylon pellets into a heat chamber.

→ As the screw rotates, a combination of pressure, friction and external heat melts the nylon.

→ Molten nylon is pumped into multi-cavity moulds for setting.

Carbon fibre composite propellers

→ A mould is laid with an impregnated carbon fibre sheet and placed into a vacuum bag.

→ An autoclave is used to evacuate the bag so the assembly can be heated and then allowed to set.

10. ENGINEERING, AE 2022 HSC 24b

Mean mark 54%.

→ The corrosion shown in the image is galvanic corrosion

→ It has occurred since the metal used for the body of the plane is not the same as the metal used for the bolts.

→ This causes galvanic corrosion as the bolts become an anode to protect the cathodic fuselage from rusting. This can also be referred to as dissimilar metal corrosion.

Pit and crevice corrosion

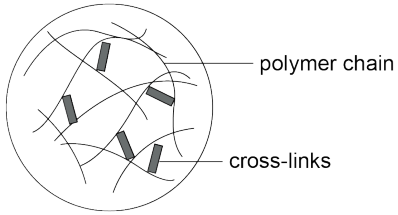
→ Although less likely, the image could also show pit and crevice corrosion (concentration cell corrosion), as it is occurring around the cracks between sheets of the fuselage.

→ This occurs when a metal is placed in an electrolyte of varying concentration. In this case there is a lower concentration of oxygen in the crack, causing the tip of the crack to become the anode and corrode.

11. ENGINEERING, AE 2023 HSC 21d

♦♦ Mean mark 36%.

→ Thermosetting polymers have a three-dimensional network structure, where polymer chains are cross-linked by covalent bonds in a network of polymer chains.



12. ENGINEERING, AE 2023 HSC 25a

♦ Mean mark 50%.

→ The process of compression moulding of aircraft components requires a polymer to be fed into an open, heated mould cavity.

→ Once the polymer is soft, the mould is then closed and compressed.

→ Compression allows the material to fill the mould entirely. The charge cures within the heated mould.

→ When the piece is cured it is removed and the mould can be reused.

13. ENGINEERING, AE 2017 HSC 26c

♦♦ Mean mark 27%.

Changes to structure and properties of the rivet

→ The microstructure of the rivet, after quenching, is a solid unstable solution of copper dissolved in aluminium.

→ On reaching room temperature, the heat energy created initiates the copper's precipitation out of solid solution as finely distributed precipitates $(\mathrm{CuAl_2})$, which strengthens the alloy considerably.

→ Work hardening is produced by cold working the metal when the rivet head is formed.

→ The rivet is significantly strengthened due to the installation, and its hardness will increase until precipitation hardening is finalised.

→ Corresponding decreases in the ductility of the metal will also be evident.