Engineering General Senior Syllabus 2019 v1.1

Subject report 2020

February 2021

Queensland Government
Queensland Curriculum & Assessment Authority

210040

For all Queensland schools

ISBN

Print version: 978-1-74378-112-8

© State of Queensland (QCAA) 2021

Licence: https://creativecommons.org/licenses/by/4.0 | **Copyright notice:** www.qcaa.qld.edu.au/copyright — lists the full terms and conditions, which specify certain exceptions to the licence. |
Attribution: '© State of Queensland (QCAA) 2021' — please include the link to our copyright notice.

Other copyright material in this publication is listed below.

1. Student responses in this report are excluded from the CC BY 4.0 licence.

Queensland Curriculum & Assessment Authority
PO Box 307 Spring Hill QLD 4004 Australia
154 Melbourne Street, South Brisbane

Phone: (07) 3864 0299
Email: office@qcaa.qld.edu.au
Website: www.qcaa.qld.edu.au

Contents

Introduction

The first summative year for the new Queensland Certificate of Education (QCE) system was unexpectedly challenging. The demands of delivering new assessment requirements and processes were amplified by disruptions to senior schooling arising from the COVID-19 pandemic. This meant the new system was forced to adapt before it had been introduced — the number of summative internal assessments was reduced from three to two in all General subjects. Schools and the QCAA worked together to implement the new assessment processes and the 2020 Year 12 cohort received accurate and reliable subject results.

Queensland's innovative new senior assessment system combines the flexibility and authenticity of school-based assessment, developed and marked by classroom teachers, with the rigour and consistency of external assessment set and marked by QCAA-trained assessment writers and markers. The system does not privilege one form of assessment over another, and both teachers and QCAA assessors share the role of making high-stakes judgments about the achievement of students. Our commitment to rigorous external quality assurance guarantees the reliability of both internal and external assessment outcomes.

Using evidence of student learning to make judgments on student achievement is just one purpose of assessment. In a sophisticated assessment system, it is also used by teachers to inform pedagogy and by students to monitor and reflect on their progress.

This post-cycle report on the summative assessment program is not simply being produced as a matter of record. It is intended that it will play an active role in future assessment cycles by providing observations and findings in a way that is meaningful and helpful to support the teaching and learning process, provide future students with guidance to support their preparations for summative assessment, and promote transparency and accountability in the broader education community. Reflection and research are necessary for the new system to achieve stability and to continue to evolve. The annual subject report is a key medium for making it accessible to schools and others.

Background

Purpose

The annual subject report is an analysis of the previous year's full summative assessment cycle. This includes endorsement of summative internal assessment instruments, confirmation of internal assessment marks and external assessment.

The report provides an overview of the key outcomes of one full teaching, learning and assessment cycle for each subject, including:

- information about the application of the syllabus objectives through the design and marking of internal and external assessments
- information about the patterns of student achievement in each subject for the assessment cycle.

It also provides advice to schools to promote continuous improvement, including:

- identification of effective practices in the design and marking of valid, accessible and reliable assessments
- identification of areas for improvement and recommendations to enhance the design and marking of valid, accessible and reliable assessment instruments
- provision of tangible examples of best practice where relevant, possible and appropriate.

Audience and use

This report should be read by school leaders, subject leaders and teachers to inform teaching and learning and assessment preparation. The report is to be used by schools and teachers to assist in assessment design practice, in making assessment decisions and in preparing students for external assessment.

The report is publicly available to promote transparency and accountability. Students, parents, community members and other education stakeholders can learn about the assessment practices and outcomes for General subjects (including alternative sequences and Senior External Examination subjects, where relevant) and General (Extension) subjects.

Report preparation

The report includes analyses of data and other information from the processes of endorsement, confirmation and external assessment, and advice from the chief confirmer, chief endorser and chief marker, developed in consultation with and support from QCAA subject matter experts.

Subject data summary

Subject enrolments

- Number of schools offering the subject: 92.

Completion of units	Unit 1	Unit 2	Units 3 and 4*
Number of students completed	1237	1262	1255

*Units 3 and 4 figure includes students who were not rated.

Units 1 and 2 results

Number of students	Satisfactory	Unsatisfactory	Not rated
Unit 1	1162	72	3
Unit 2	1193	67	2

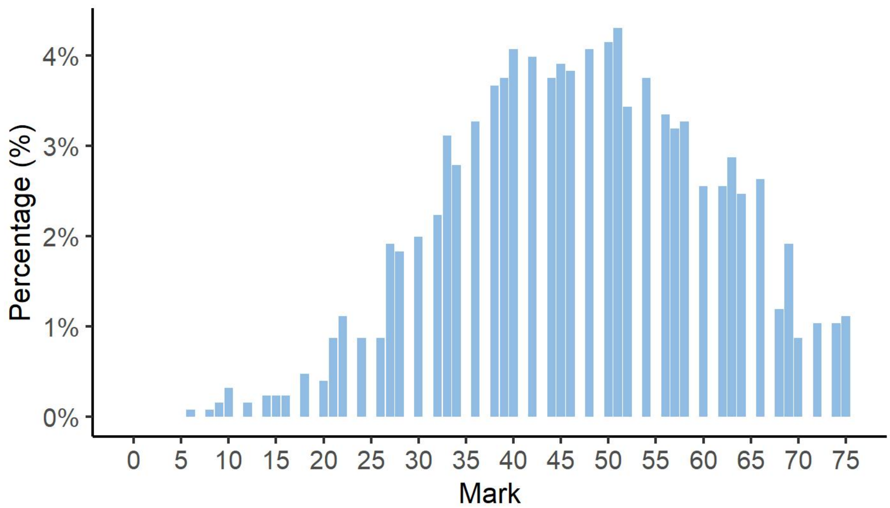
Units 3 and 4 internal assessment results

2020 COVID-19 adjustments

To support Queensland schools, teachers and students to manage learning and assessment during the evolving COVID-19 pandemic in 2020, the QCAA Board approved the removal of one internal assessment for students completing Units 3 and 4 in General and Applied subjects.

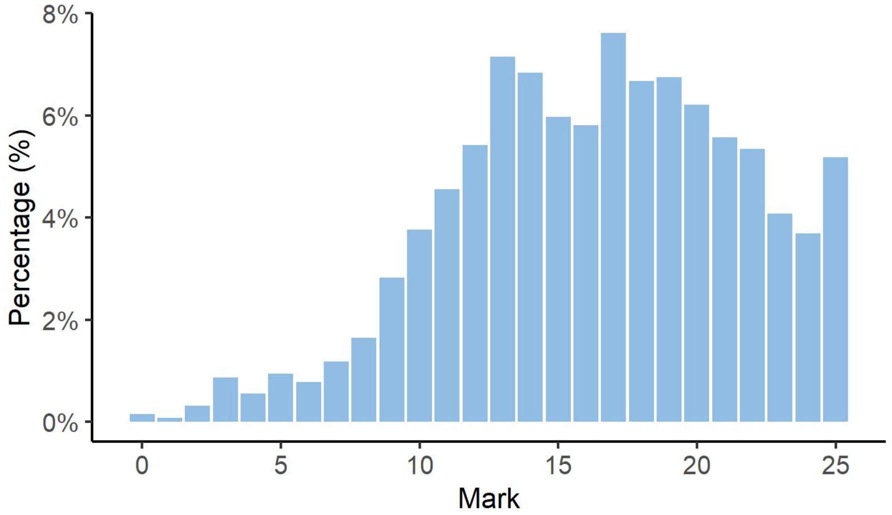
In General subjects, students completed two internal assessments and an external assessment. Schools made decisions based on QCAA advice and their school context. Therefore, across the state some instruments were completed by most schools, some completed by fewer schools and others completed by few or no schools. In the case of the latter, the data and information for these instruments has not been included.

Total results for internal assessment

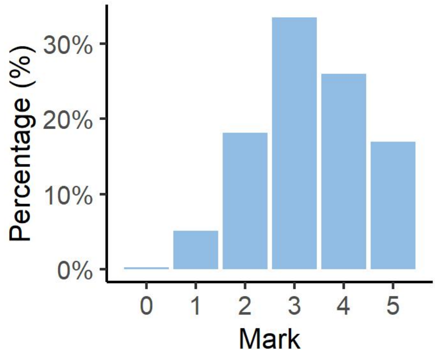


IA1 results

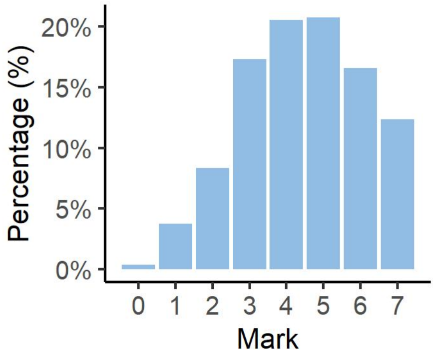
IA1 total



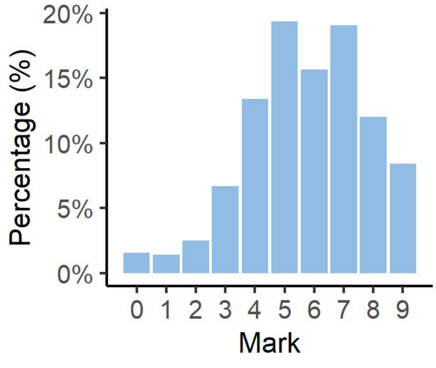
IA1 Criterion 1



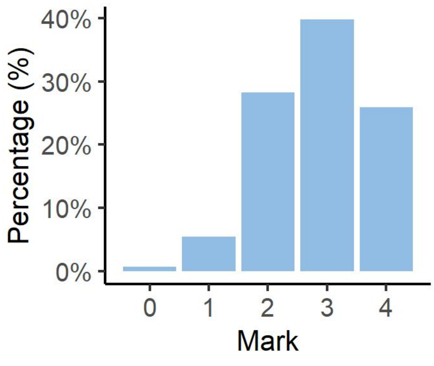
IA1 Criterion 2



IA1 Criterion 3

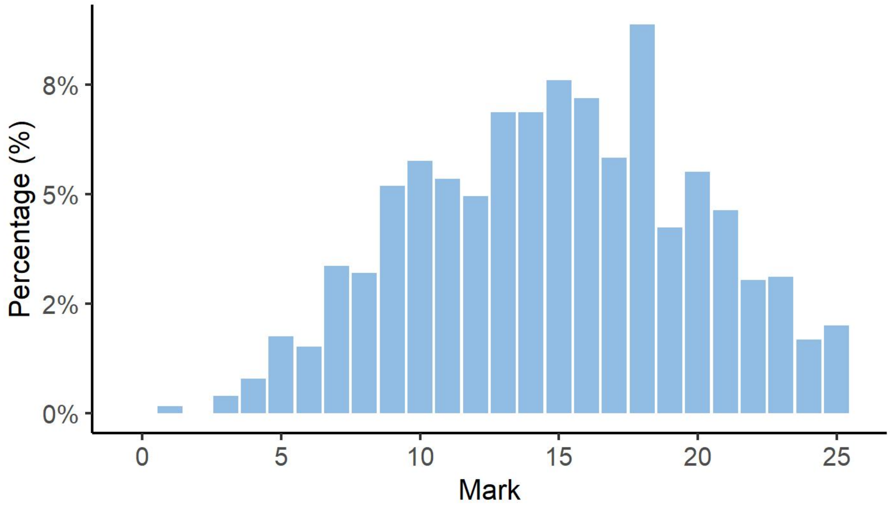


IA1 Criterion 4

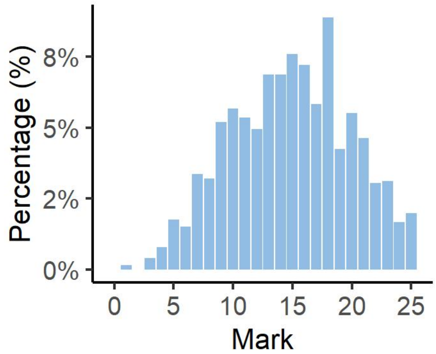


IA2 results

IA2 total



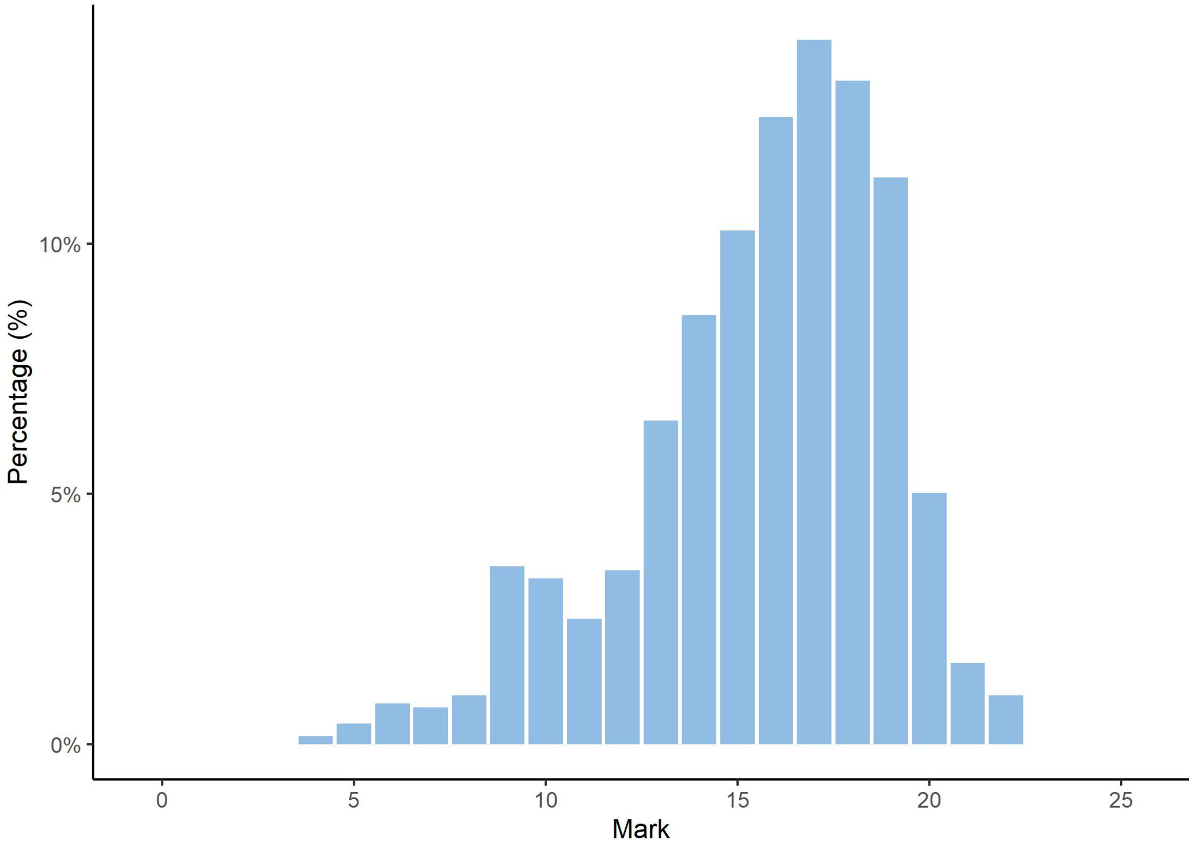
IA2 Criterion 1



IA3 results

Due to COVID-19 pandemic adjustments, there were insufficient student responses to this instrument to provide useful analytics.

External assessment results



Final standards allocation

The number of students awarded each standard across the state are as follows.

Standard	A	B	C	D	E
Number of students	168	386	576	100	7

Grade boundaries

The grade boundaries are determined using a process to compare results on a numeric scale to the reporting standards.

Standard	A	B	C	D	E
Marks achieved	100–82	81–66	65–42	41–20	19–0

Internal assessment

The following information and advice pertain to the assessment design and assessment decisions for each IA in Units 3 and 4. These instruments have undergone quality assurance processes informed by the attributes of quality assessment (validity, accessibility and reliability).

Endorsement

Endorsement is the quality assurance process based on the attributes of validity and accessibility. These attributes are categorised further as priorities for assessment and each priority can be further broken down into assessment practices. Data presented in the assessment design sections identifies the reasons why IA instruments were not endorsed at Application 1, by the priority for assessments. An IA may have been identified more than once for a priority for assessment, e.g. it may have demonstrated a misalignment to both subject matter and to the assessment objective. Refer to the quality assurance tools for detailed information about the assessment practices for each assessment instrument.

Total number of items endorsed in Application 1

Number of items submitted each event	IA1	IA2	IA3
Total number of instruments	92	92	92
Percentage endorsed in Application 1	33	25	45

Confirmation

Confirmation is the quality assurance process based on the attribute of reliability. Teachers make judgments about the evidence in students' responses using the instrument-specific marking guide (ISMG) to indicate the alignment of students' work with performance-level descriptors and determine a mark for each criterion. These are provisional criterion marks. The QCAA makes the final decision about student results through the confirmation processes. Data presented in the assessment decisions section identifies the level of agreement between provisional and final results.

Number of samples reviewed at initial, supplementary and extraordinary review

IA	Number of schools	Number of samples requested	Supplementary samples requested	Extraordinary review	School review	Percentage agreement with provisional
1	92	466	65	33	4	95.91
2	91	505	0	0	0	99.6

Internal assessment 1 (IA1)

Project — Folio (25%)

This assessment focuses on the problem-solving process in Engineering that requires the application of a range of cognitive, technical and creative skills and theoretical understandings in relation to Unit 3 subject matter and objectives. The response is a coherent work that documents the iterative process undertaken to develop an engineered solution to a civil structural problem using a project — folio (Syllabus section 4.6.1).

Assessment design

Validity

Validity in assessment design considers the extent to which an assessment item accurately measures what it is intended to measure and that the evidence of student learning collected from an assessment can be legitimately used for the purpose specified in the syllabus.

Reasons for non-endorsement by priority of assessment — validity practices

Validity priority	Number of times priority was identified in decisions*
Alignment	23
Authentication	18
Authenticity	19
Item construction	9
Scope and scale	10

*Total number of submissions: 92. Each priority might contain up to four assessment practices.

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that featured:

- real-world contexts that included sufficient detail about the structural engineering problem, e.g. the contextual information required students to recognise the characteristics of the structural problem in order to authentically engage in the problem-solving process
- opportunities to use Unit 3 syllabus subject matter in relation to engineering technology knowledge, and mechanics and materials science concepts and principles in relation to structures, e.g. the forces exerted on and resisted by structures and the materials used in construction, the consideration of environment, weather, economic and social factors
- contexts that included sufficient detail about the structural problem and were also of appropriate scope
- clear information about the size and requirements (valid force and dimension scale) for the generation of the physical prototype solution and testing that provided valid and credible performance data.

Practices to strengthen

It is recommended that assessment instruments:

- give students the opportunity to provide evidence that aligns with the assessment specifications, e.g. the syllabus assessment specifications are included without alteration and teachers determine whether the evidence required by the specifications is able to be provided in the student response given the information included in the structural problem context

- provide a clear description about the purpose for the prototype solution within the broader real-world structural problem context. It is important that students understand that the purpose for the prototype within the problem-solving process is to provide data that can be used to evaluate and refine the structural problem solution in relation to success criteria
- develop a structural problem context that suits the local school context and is sufficiently different from the QCAA sample IA1 instrument to ensure students are able to demonstrate unique responses
- only include scaffolding (images) where absolutely necessary, and when included provide students with the opportunity to develop unique responses, e.g. images of bridges, cranes or lifting devices lead students to a predetermined solution. Additionally, it is not appropriate for assessment instruments to refer students to the QCAA samples or to provide students with project — folio headings.

Accessibility

Accessibility in assessment design ensures that no student or group of students is disadvantaged in their capacity to access an assessment.

Reasons for non-endorsement by priority of assessment — accessibility practices

Accessibility priority	Number of times priority was identified in decisions*
Transparency	6
Language	11
Layout	0
Bias avoidance	7

*Total number of submissions: 92. Each priority might contain up to four assessment practices.

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that featured:

- a clear layout for the assessment specifications that aligns with the syllabus (Syllabus section 4.6.1)
- appropriate stimulus images that met with task requirements, e.g. an image of a particular locality that provides relevant information in relation to the environmental and social implications of the development of a structure.

Practices to strengthen

It is recommended that assessment instruments:

- use syllabus terminology in the form of cues that align with the assessment specifications, objectives and ISMG, e.g. referring to the mitigation of environmental and sustainability impacts in the problem context prompts students to provide evidence that aligns with the objectives, specifications and ISMG
- use the language of problem-solving in Engineering syllabus subject matter (Syllabus section 1.2.4) and not include ‘design or designing’ as these concepts are not defined

- use contexts that are accessible to students, such as those that relate to the real world and that require students to apply syllabus subject matter without placing students in professional roles.

Assessment decisions

Reliability

Reliability is a judgment about the measurements of assessment. It refers to the extent to which the results of assessments are consistent, replicable and free from error.

Agreement trends between provisional and final results

Criterion number	Criterion name	Percentage agreement with provisional	Percentage less than provisional	Percentage greater than provisional
1	Retrieving and comprehending	97.79	2.06	0.16
2	Analysing	94.62	5.38	0
3	Synthesising and evaluating	93.44	6.48	0.08
4	Communicating	97.79	2.21	0

Effective practices

Accuracy and consistency of the application of the ISMG for this IA was most effective when:

- matching qualities in student responses with the Retrieving and comprehending and Communicating criteria for all performance levels
- judgments were most often made consistently with reference to the evidence provided in student responses for these two criteria.

Samples of effective practices

The following are excerpts from responses that illustrate the characteristics for the criteria at the performance level indicated. The samples may provide evidence of more than one criterion. The characteristics highlighted are not the only time the characteristics have occurred throughout the responses.

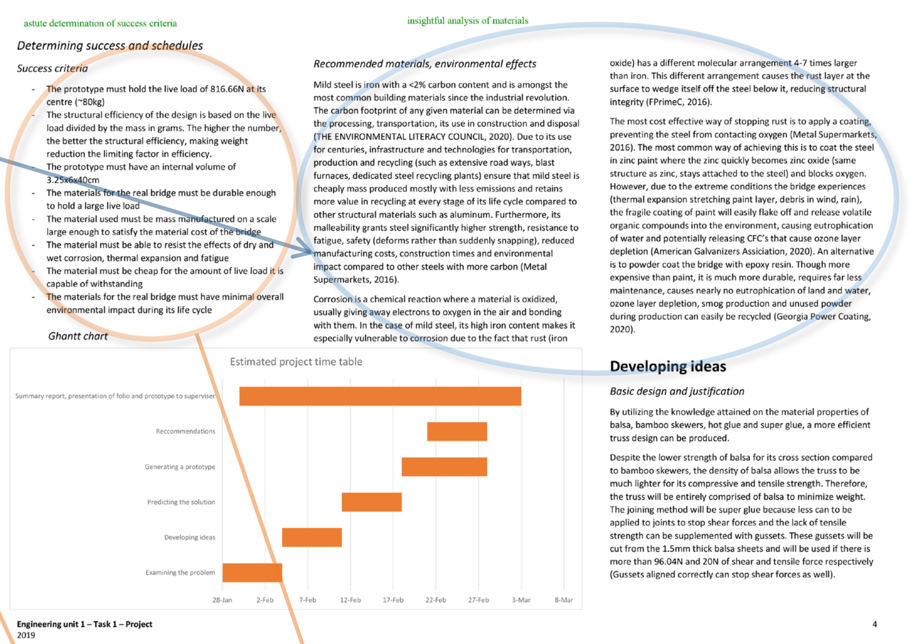
Retrieving and comprehending (4–5 marks)

The response provides evidence of the consistently correct identification of the characteristics of the structural problem, with thoughtful and astute choices made in the selection and use of engineering technology knowledge and materials science concepts and principles.

Analysing (6–7 marks)

This response provides evidence of an accurate assessment of the problem characteristics to establish success criteria that are of critical importance for ascertaining a structural problem solution.

The success criteria acknowledge that the prototype is essential to, but not more important than, the development of the engineered solution to the broader real-world bridge structural problem.



astute determination of success criteria

Determining success and schedules

Success criteria

- The prototype must hold the live load of 816.66N at its centre (~80kg)
- The structural efficiency of the design is based on the live load divided by the mass in grams. The higher the number, the better the structural efficiency, making weight reduction the limiting factor in efficiency.
- The prototype must have an internal volume of 3.25x6x40cm
- The materials for the real bridge must be durable enough to hold a large live load
- The material used must be mass manufactured on a scale large enough to satisfy the material cost of the bridge
- The material must be able to resist the effects of dry and wet corrosion, thermal expansion and fatigue
- The material must be cheap for the amount of live load it is capable of withstanding
- The materials for the real bridge must have minimal overall environmental impact during its life cycle

Ghantt chart

insightful analysis of materials

Recommended materials, environmental effects

Mild steel is iron with a <2% carbon content and is amongst the most common building materials since the industrial revolution. The carbon footprint of any given material can be determined via the processing, transportation, its use in construction and disposal (THE ENVIRONMENTAL LITERACY COUNCIL, 2020). Due to its use for centuries, infrastructure and technologies for transportation, production and recycling (such as extensive road ways, blast furnaces, dedicated steel recycling plants) ensure that mild steel is cheaply mass produced mostly with less emissions and retains more value in recycling at every stage of its life cycle compared to other structural materials such as aluminum. Furthermore, its malleability grants steel significantly higher strength, resistance to fatigue, safety (deforms rather than suddenly snapping), reduced manufacturing costs, construction times and environmental impact compared to other steels with more carbon (Metal Supermarkets, 2016).

Corrosion is a chemical reaction where a material is oxidized, usually giving away electrons to oxygen in the air and bonding with them. In the case of mild steel, its high iron content makes it especially vulnerable to corrosion due to the fact that rust (iron oxide) has a different molecular arrangement 4-7 times larger than iron. This different arrangement causes the rust layer at the surface to wedge itself off the steel below it, reducing structural integrity (FPrimeC, 2016).

The most cost effective way of stopping rust is to apply a coating, preventing the steel from contacting oxygen (Metal Supermarkets, 2016). The most common way of achieving this is to coat the steel in zinc paint where the zinc quickly becomes zinc oxide (same structure as zinc, stays attached to the steel) and blocks oxygen. However, due to the extreme conditions the bridge experiences (thermal expansion stretching paint layer, debris in wind, rain), the fragile coating of paint will easily flake off and release volatile organic compounds into the environment, causing eutrophication of water and potentially releasing CFC's that cause ozone layer depletion (American Galvanizers Assiciation, 2020). An alternative is to powder coat the bridge with epoxy resin. Though more expensive than paint, it is much more durable, requires far less maintenance, causes nearly no eutrophication of land and water, ozone layer depletion, smog production and unused powder during production can easily be recycled (Georgia Power Coating, 2020).

Developing ideas

Basic design and justification

By utilizing the knowledge attained on the material properties of balsa, bamboo skewers, hot glue and super glue, a more efficient truss design can be produced.

Despite the lower strength of balsa for its cross section compared to bamboo skewers, the density of balsa allows the truss to be much lighter for its compressive and tensile strength. Therefore, the truss will be entirely comprised of balsa to minimize weight. The joining method will be super glue because less can to be applied to joints to stop shear forces and the lack of tensile strength can be supplemented with gussets. These gussets will be cut from the 1.5mm thick balsa sheets and will be used if there is more than 96.04N and 20N of shear and tensile force respectively (Gussets aligned correctly can stop shear forces as well).

Engineering unit 1 – Task 1 – Project
2019

4

Success criteria

- The prototype must hold the live load of 816.66N at its centre (~80kg)
- The structural efficiency of the design is based on the live load divided by the mass in grams. The higher the number, the better the structural efficiency, making weight reduction the limiting factor in efficiency.
- The prototype must have an internal volume of 3.25x6x40cm
- The materials for the real bridge must be durable enough to hold a large live load
- The material used must be mass manufactured on a scale large enough to satisfy the material cost of the bridge
- The material must be able to resist the effects of dry and wet corrosion, thermal expansion and fatigue
- The material must be cheap for the amount of live load it is capable of withstanding
- The materials for the real bridge must have minimal overall environmental impact during its life cycle

Communicating (3–4 marks)

This response provides evidence of the use of written and visual features that are selected for their value and relevance and are structured to provide an articulate and thoughtful presentation of information.

The response includes the use and thoughtful presentation of language and grammatically accurate language structures selected for their value and relevance to a technical audience.

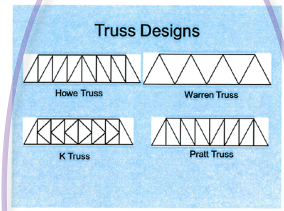
Synthesising and evaluating (8–9 marks)

This response provides evidence of a well-structured, rational and valid combining and integrating of engineering mechanics, information and ideas that have a direct bearing on predicting a possible structural solution.

Developing Ideas

POSSIBLE SOLUTIONS

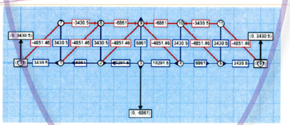
The restraints given by the school suggests that the bridge built must be of a truss-style. The three most common of the truss styled bridges are the Howe, Warren, K and Pratt truss (Machines4U.com.au, 2017).



Math analysis

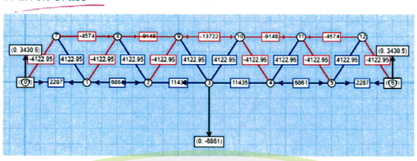
Math analysis done on truss simulator from JHU Engineering innovation (Johns Hopkins University, 2019). It is with this analysis and prior testing a type of bridge will be selected.

Howe Truss



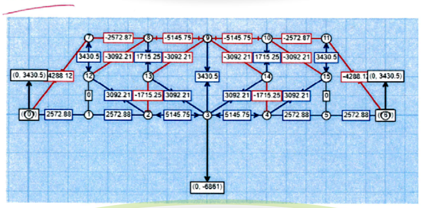
The Howe truss has the majority of its menbers that take high forces under compression(indicated by the red lines). It is known that balsa wood performs at its best when under tension and thus this design would not be the most effective. On the positive side bridge is also somewhat efficient considering that there are an average amount of members. This model does however show that there will be large forces going through the tension members, which could easily lead to snapping.

Warren Truss



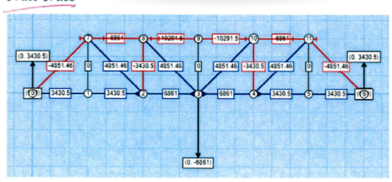
The Warren Truss relies on many of the exact same members put together in equilateral triangles. This truss spreads the force evenly throughout the structure however, the forces traveling through the members are extremely large. This truss also has the benefit of being economically efficient as the total size of this bridge is smaller thus making it more efficient.

K Truss



Like the Warren the K Truss also spreads the force from the center of the bridge out. This bridge however, has a much larger amount of members which all carry a lower force. This suggests that it could be the strongest and may not need extra beams for double laminating.

Pratt Truss



The Pratt truss has the same attributes to the Howe truss however the majority of its high force carrying members are in tension. Having the forces in tesnion will be a benefit for this experiment as it is a known factor and has been confirmed through testing that balsa wood is very good under tension in comparrison to compression.

How did they perform?

It appears through the simulated testing the K Truss design would spread the force more evenly but would also have a large amount of force going through the outside members (0-7 and 6-11) and also the members at the top of the truss (8-9 and 9-10) this suggests that it might be beneficial that it should be double layered and also properly gusseted when constructed. Both the Howe and Pratt truss performed similarly with the same forces going through different members with the exception of some zero force members in the Pratt truss design.

SOLUTION SUCCESS CRITERIA

The success criteria were finalized to essentially do two things hold the required mass with the smallest mass and to have a minimal environmental impact.

In order to do this, one of the criteria was that the truss bridge structure's efficiency will be determined using the beam performance index: mass supported in grams divided by mass of beams in grams. However, for this to be valid it will have to reach 28 Kg which is the minimum mass for the bridge to hold according to the restraints with the factor of safety included.

It is also noted that for the prototype resources will be limited to a minimal amount of balsa wood strips. The strips had the dimensions as follows: width of 6.5mm height of 6.5mm and a length of 900mm. The build of the prototype will also require other materials such as manila folder and balsa cement which is required to make the structure stronger and support the applied loads (274.86N vertically down(28kg)) and to keep the structures mass to a minimum.

For the final product the materials of the bridge are to be corrosion resistant, withstand the effects of heat by allowing the bridge to expand and contract while also allowing for construction onsite after fabrication of significant components off site and transportation to Norman Creek High School.

Finally, one of the most important factors is that the structure should not impact negatively on the environment and be easily maintained over its useful life and be recyclable when no longer required. Upon construction there should be no adverse impact on the habitat or create increased risk of erosion during or after construction.

Synthesising and evaluating (8–9 marks)

This response provides evidence of the use of rational judgement and logical consistency when assigning merit to ideas and a solution. The data, including research information, test results and calculations, have been used to assess for strengths, weaknesses, implications and limitations, and to make thoughtful and accurate recommendations. Skilful judgements have been made about the suitability of ideas and the solution with reference to success criteria.

Practices to strengthen

To further ensure accuracy and consistency of the application of the ISMG in this IA, it is recommended that:

- schools further examine the Analysing criterion performance-level descriptors to ensure consistency of the match with evidence in student responses, e.g. at the 6–7 performance level, responses should include evidence of the astute determination of essential success criteria. This requires that students provide an accurate assessment of the structural problem's characteristics to establish success criteria that are of critical importance for ascertaining an engineered solution. To accurately assess the problem's characteristics at the 6–7 performance level requires that students provide evidence of insightful analysis of the structural problem, and relevant engineering mechanics, materials science, technology and research information. The student work at this level should include evidence that indicates the student's understanding of the relationships that exist in complex situations to distinguish the problem's characteristics using pertinent engineering mechanics, materials science, technology and research information
- schools further examine the Synthesising and evaluating criterion performance level descriptors to ensure consistency of the match with evidence in student responses, e.g. evaluation and refinement should apply to the structural problem solution, rather than primarily on the performance of the prototype when tested. This testing should be used to make recommendations for modifications to the structural problem solution in the broader problem context. Evidence that aligns with the 8–9 performance-level descriptor requires that students demonstrate rational judgment and logical consistency when assigning merit to ideas and a solution to the structural problem. Students should use data, including research information, test results and calculations to assess for strengths, weaknesses, implications and limitations, and to make thoughtful and accurate recommendations. Skilful judgments should be made about the suitability of ideas and the solution with reference to success criteria
- schools identify the differences between each performance-level descriptor for the Analysing and Synthesising and evaluating criteria in terms of the expected evidence in student responses to make consistent decisions.

Internal assessment 2 (IA2)

Examination — short response (25%)

The short response examination assesses the application of a range of cognitions to multiple provided items drawn from across Unit 3 subject matter in each topic. The examination must assess a balance across the assessment objectives and the percentage allocation of marks must match the degree of difficulty specifications: ~20% complex unfamiliar, ~20% complex familiar, ~60% simple familiar. Student responses must be completed individually, under supervised conditions, and in the set timeframe (Syllabus section 4.6.2).

Assessment design

Validity

Validity in assessment design considers the extent to which an assessment item accurately measures what it is intended to measure and that the evidence of student learning collected from an assessment can be legitimately used for the purpose specified in the syllabus.

Reasons for non-endorsement by priority of assessment — validity practices

Validity priority	Number of times priority was identified in decisions*
Alignment	45
Authentication	0
Authenticity	20
Item construction	27
Scope and scale	11

*Total number of submissions: 92. Each priority might contain up to four assessment practices.

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that featured:

- a balance across the assessment objectives using a number of item types including, multiple-choice, single-word, sentence, short-paragraph and calculation responses
- items that matched with the syllabus degree of complexity specifications for simple familiar and complex familiar questions (Syllabus section 4.6.2)
- items that allowed for unique student responses
- items that were carefully constructed using the appropriate cognitions that aligned with the assessment objectives.

Practices to strengthen

It is recommended that assessment instruments:

- include items that assess Unit 3 subject matter only, e.g. the planned obsolescence of products such as mobile phones is not included in Unit 3 subject matter. However, the planned obsolescence of structures, such as houses and high-rise buildings, does align to Unit 3 subject matter

- structure complex unfamiliar questions so that all the information to solve the problem is not immediately identifiable. Students should engage in sustained analysis and synthesis of relevant information to develop a response to a complex unfamiliar question
- develop items that suit the local school context and are sufficiently different from the QCAA sample instrument to ensure students are able to demonstrate authentic responses
- include multiple choice items that are carefully constructed to align with the conventions for this item type, e.g. multiple choice questions should have distractors that are plausible for some students. Distractors that are obviously incorrect must not be included, because they negatively impact on question validity
- include an appropriate number of questions and an expected student response that adheres to the syllabus conditions for the technique, e.g. marking scheme sample student responses for short-paragraph questions should be limited to 100–150 words per item.

Accessibility

Accessibility in assessment design ensures that no student or group of students is disadvantaged in their capacity to access an assessment.

Reasons for non-endorsement by priority of assessment — accessibility practices

Accessibility priority	Number of times priority was identified in decisions*
Transparency	6
Language	11
Layout	3
Bias avoidance	5

*Total number of submissions: 92. Each priority might contain up to four assessment practices.

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that featured:

- an alignment of the response space available for each item, with the length of the sample response in the marking scheme
- a logical, well-structured layout with an adequate and effective use of white space
- items that avoided bias and inappropriate content, e.g. use of gender-neutral language and contexts.

Practices to strengthen

It is recommended that assessment instruments:

- provide clear instructions using cues that align with the cognitions in the assessment objectives, e.g. questions that require students to analyse graphical or written information should use instructions such as *determine*, *interpret* and *examine* to clearly inform students about the cognition involved and the type of response required
- include appropriate and technically correct language and that the meanings for terms and definitions align with the syllabus, e.g. a life cycle assessment of the use of an engineering material quantifies the environmental impact rather than the financial impact of its extracting and processing, manufacturing, transporting and distribution, use, reuse and maintenance, recycling and final disposal

- use engineering situations to contextualise items that do not place the student in professional roles or inappropriate engineering contexts, e.g. questions should maintain a focus on civil structures as detailed in Unit 3 subject matter in each topic.

Assessment decisions

Reliability

Reliability is a judgment about the measurements of assessment. It refers to the extent to which the results of assessments are consistent, replicable and free from error.

Agreement trends between provisional and final results

Criterion number	Criterion name	Percentage agreement with provisional	Percentage less than provisional	Percentage greater than provisional
1	Engineering knowledge and problem-solving	99.6	0.24	0.16

Effective practices

Accuracy and consistency of the application of the ISMG for this IA was most effective when:

- ISMG cut-offs were correctly applied using an accurate percentage calculation for each student's examination result
- school-developed marking schemes were accurately and consistently applied to all student responses within a school cohort.

Practices to strengthen

To further ensure accuracy and consistency of the application of the ISMG in this IA, it is recommended that:

- examination papers are cross-marked to ensure that the total marks awarded are indicated and accurate, and that the ISMG cut-offs have been accurately and consistently applied using the correct percentage result
- the examination paper clearly indicates the alignment of marks awarded for each question with the school-developed marking scheme
- the total marks awarded for each question are clearly provided on the paper.

Internal assessment 3 (IA3)

Project — folio (25%)

This assessment focuses on the problem-solving process in Engineering that requires the application of a range of cognitive, technical and creative skills and theoretical understandings in relation to Unit 4 subject matter and objectives. The response is a coherent work that documents the iterative process undertaken to develop an engineered solution to a mechanical and/or mechanisms problem using a project — folio (Syllabus section 5.6.1).

Assessment design

Validity

Validity in assessment design considers the extent to which an assessment item accurately measures what it is intended to measure and that the evidence of student learning collected from an assessment can be legitimately used for the purpose specified in the syllabus.

Reasons for non-endorsement by priority of assessment — validity practices

Validity priority	Number of times priority was identified in decisions*
Alignment	39
Authentication	2
Authenticity	2
Item construction	4
Scope and scale	7

*Total number of submissions: 92. Each priority might contain up to four assessment practices.

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that featured:

- real-world contexts that included sufficient detail about the mechanical and/or mechanisms engineering problem, e.g. the contextual information required students to recognise the characteristics of the mechanical and/or mechanisms problem in order to authentically engage in the problem-solving process
- opportunities to use Unit 4 syllabus subject matter in relation to engineering technology knowledge, and mechanics, materials science and control technologies concepts and principles in relation to machines and mechanisms, e.g. the context included information that required students to incorporate knowledge and research about machine control technologies, which aligns with the evidence required in the syllabus assessment objectives, specifications and ISMG (Syllabus section 5.6.1)
- contexts that included sufficient detail about the mechanical and/or mechanisms problem and were also of appropriate scope
- clear information about the size and requirements for the generation of the physical or virtual prototype solution and testing that provided valid and credible performance data that can be used to evaluate and refine predicted solutions.

Practices to strengthen

It is recommended that assessment instruments:

- provide a clear description about the purpose for the prototype solution within the broader real-world mechanical and/or mechanisms problem context. It is important that students understand that the purpose for the prototype within the problem-solving process is to provide data that can be used to evaluate and refine the mechanical and/or mechanisms problem solution in relation to success criteria
- develop a mechanical and/or mechanisms problem context that suits the local school context and is sufficiently different from the QCAA sample IA1 instrument to ensure students are able to demonstrate unique responses
- only include scaffolding (images) where absolutely necessary, and when included provide students with the opportunity to develop unique responses, e.g. images of possible solutions or aspects of solutions leads students to predetermined solutions. Scaffolding should be limited to aspects of the problem that require contextual information only, such as the immediate machine or mechanism's working environment. Additionally, it is not appropriate for assessment instruments to refer students to the QCAA samples or to provide students with project — folio headings.

Accessibility

Accessibility in assessment design ensures that no student or group of students is disadvantaged in their capacity to access an assessment.

Reasons for non-endorsement by priority of assessment — accessibility practices

Accessibility priority	Number of times priority was identified in decisions*
Transparency	6
Language	1
Layout	0
Bias avoidance	2

*Total number of submissions: 92. Each priority might contain up to four assessment practices.

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that featured:

- information in the form of cues that aligned with the syllabus assessment specifications, objectives and ISMG, e.g. providing students with information in the problem context that links to the environmental and sustainability impacts associated with the mechanical and/or mechanisms problem, including corrosion, life cycle assessment, safety, pollution, maintenance and energy efficiency prompts students to provide evidence that aligns with the assessment specifications, objectives and ISMG
- a clear layout for the assessment specifications that aligned with the syllabus (Syllabus section 5.6.1).

Practices to strengthen

It is recommended that assessment instruments:

- use problem-solving language in Engineering syllabus subject matter and not include 'design or designing' as these concepts are not defined

- use contexts that are accessible to students, such as those that relate to the real world and that require students to apply syllabus subject matter without placing students in professional roles.

Assessment decisions

Due to COVID-19 pandemic adjustments, there were insufficient student responses to this instrument to provide useful analytics.

External assessment

Examination: Short response

Assessment design

Assessment specifications and conditions

Short response

- consists of a number of items that may ask students to respond to the following activities
  - sketching, drawing, graphs, tables and diagrams
  - writing multiple-choice, single-word, sentence or short-paragraph responses drawn from Unit 4 subject matter in each topic
  - calculating using formulas drawn from across Unit 4 subject matter
  - responding to seen or unseen stimulus materials
- where applicable, students are required to write in full sentences, constructing a response so that ideas are maintained, developed and justified
- the examination must assess a balance across the assessment objectives
- the percentage allocation of marks must match the degree of difficulty specifications: ~20% Complex unfamiliar, ~20% Complex familiar, ~60% Simple familiar.

Conditions

- Time: 2 hours plus perusal (10 minutes)
- Length: 800–1000 words in total or equivalent, including
  - a number of multiple-choice, single-word or sentence response items
  - a number of short-paragraph response items of 100–150 words per item
  - a number of items requiring calculations.
- Other:
  - only the QCAA formula sheet must be provided
  - notes are not permitted
  - use of technology is required: non-programmable scientific calculator only permitted
  - protractor and ruler required.

The assessment instrument consisted of three sections. Questions were derived from the context of Unit 4 subject matter in Topic 1: Machines in society, Topic 2: Materials and Topic 3: Machine control. The assessment examined student understanding of the application of engineering dynamics principles and concepts involving machines and mechanisms, the properties of materials used in machine and mechanism manufacture and machine control.

The subject matter examined included:

- mechanical advantage and velocity ratio
- work, power and energy

- the uniform accelerated motion of objects in one dimension, apparent weight, and motion on an inclined plane
- the effect of frictional forces on the motion of objects
- the functional requirements of machines and mechanisms, including
  - material properties, chemical composition and structure
  - real-world applications, including logic control.

This assessment was used to determine student achievement in the following assessment objectives:

1. recognise and describe machine and mechanism problems, and mechanics, materials science and control technologies concepts and principles, in relation to machines and mechanisms
2. symbolise and explain ideas and solutions in relation to machines and mechanisms
3. analyse machine and mechanism problems, and information in relation to machines and mechanisms
5. synthesise information and ideas to predict possible machine and mechanism solutions.

Note: Objectives 4, 6, 7 and 8 are not assessed in this instrument.

Section 1 included 10 multiple choice simple familiar questions worth 10 marks.

Section 2 included 7 short response questions worth 35 marks. The section included 6 simple familiar questions worth 29 marks and 1 complex familiar question worth 6 marks.

Section 3 included 6 calculation questions worth 40 marks. The section included 2 simple familiar questions worth 10 marks, 2 complex familiar questions worth 12 marks and 2 complex unfamiliar questions worth 18 marks.

Assessment decisions

Overall, students responded well to the following assessment aspects:

- recognising and describing mechanics, materials science and control technologies concepts and principles in situations where relationships and interactions were obvious and had few elements
- explaining concepts and principles in relation to mechanics and materials science and engineering technology knowledge subject matter
- calculating to determine solutions to problems where relationships and interactions were obvious and had few elements, and all of the information to solve the problem was clearly provided in the question.

Effective practices

The following samples were selected to illustrate highly effective student responses in some of the assessment objectives of the syllabus.

Multiple choice item response

QUESTION 7

A 20 kg box sits just on the point of sliding on an incline plane. If the coefficient of static friction is 0.27, what is the angle of repose?

(A) 5°

(B) 13°

(C) 15°

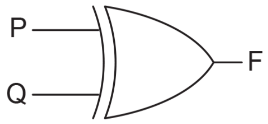
(D) 16°

Key (C) 15° — inverse tan of μ_s (0.27)

Validity argument:

- Distractors should be plausible to some students:
  - Distractor (A) 5° — 20 kg x 0.27 (information provided in the question)
  - Distractor (B) 13° — 196 N (f_N) divided by inverse tan 0.27
  - Distractor (D) 16° — inverse sin 0.27 rather than inverse tan 0.27.

QUESTION 8



The truth table that corresponds to this logic gate is

(A)

P	Q	F
0	0	0
0	1	1
1	0	1
1	1	0

(B)

P	Q	F
0	0	0
0	1	0
1	0	0
1	1	1

(C)

P	Q	F
0	0	1
0	1	1
1	0	1
1	1	0

(D)

P	Q	F
0	0	1
0	1	0
1	0	0
1	1	0

Key (A) correct corresponding truth table for the XOR logic gate provided

Validity argument:

- Distractors should be plausible to some students:
  - Distractor (B) — AND logic gate truth table
  - Distractor (C) — NAND logic gate truth table
  - Distractor (D) — NOR logic gate truth table.

Short response

Assessment objectives: 1 and 2

Item: Question 17

This question required students to explain how the chemical composition of high-carbon steel contributes to two of its mechanical properties in the context of two industrial applications.

Effective student responses:

- provided an appropriate and detailed explanation including:
  - the carbon content of 0.6% to 1.25%
  - the microstructure of either pearlite and/or ferrite and cementite and how the microstructure contributed to two appropriate mechanical properties of high-carbon steel
  - two appropriate industrial uses that aligned with the identified mechanical properties.

This sample has been included to:

- illustrate a high-level response that includes an appropriate level of detail to clearly explain how the chemical composition of high-carbon steel contributes to two of its mechanical properties in the context of two industrial applications.

High-level response (5 marks)	**QUESTION 17 (5 marks)** Explain how the chemical composition of high-carbon steel contributes to two of its mechanical properties in the context of two industrial applications. High carbon steel consists of between 0.60% and 1.25% carbon by weight. As such, it consists of a large quantity of cementite and a smaller quantity of ferrite. The cementite provides the material its stiffness and hardness. This makes high carbon steel ideal for industrial knives, which must be able to maintain their shape under stress and remain abrasion resistant. The small quantity of ferrite provides this steel with a degree of toughness, which, coupled with its strength from cementite, makes it an ideal material for high strength springs, which must absorb energy through minimal deformation.

Assessment objectives: 3 and 5

Item: Question 21

This question required students to use and annotate the binary equilibrium diagram for an alloy of metals A and B to calculate the percentage proportion of solid and liquid material present for an alloy of 50% metal A and B at 1400 °C. The answer was required to the nearest whole unit.

Effective student responses included:

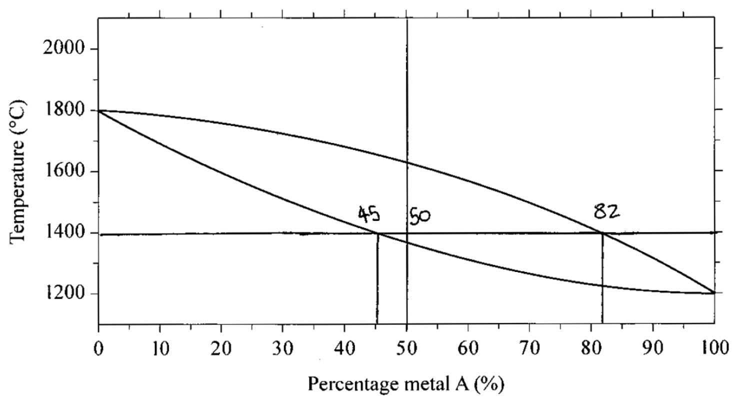
- an accurately annotated diagram to plot percentage of metals A and B at 1400 °C
- correct use of the inverse lever rule to calculate the percentage proportion of solid and liquid for a 50% metal A and B alloy at 1400 °C to the nearest whole unit.

This sample has been included to:

- illustrate a high-level response that clearly details the use of the diagram and inverse lever rule. This information is used to determine through calculation the percentage proportion of solid and liquid material present for an alloy of 50% metal A and B at 1400 °C to the nearest whole unit.

High-level response (5 marks)

QUESTION 21 (5 marks)



Use and annotate the binary equilibrium diagram for an alloy of metals A and B to calculate the percentage proportion of solid and liquid material present for an alloy of 50% metal A and B at 1400 °C. Answer to the nearest whole unit.

Note: If you make a mistake in the diagram, cancel it by ruling a single diagonal line through your work and use the additional response space on page 22 of this question and response book.

Solidus = $\frac{82-50}{82-45} \times 100$

$= \frac{32}{37} \times 100$

$= 86.486$

$= 86\%$

Solidus + Liquidous = 100%

86% + Liquidous = 100%

Liquidous = 14%

∴ Solidus = 86%

Liquidous = 14%

Assessment objectives: 3 and 5

Item: Question 22

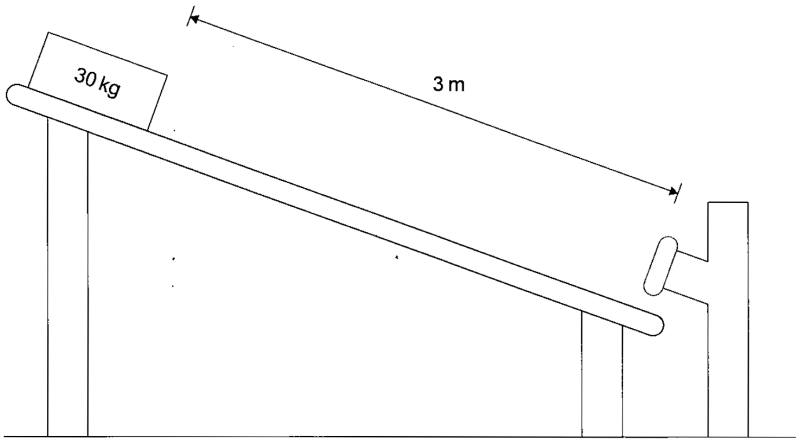
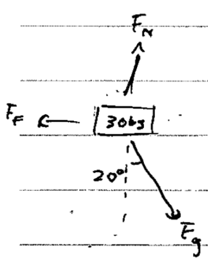
This question required students to determine the difference between the coefficients of friction for a modified luggage chute and the original with a cushioning device. This was a complex unfamiliar question, which required students to analyse the provided information to determine a solution to two decimal places.

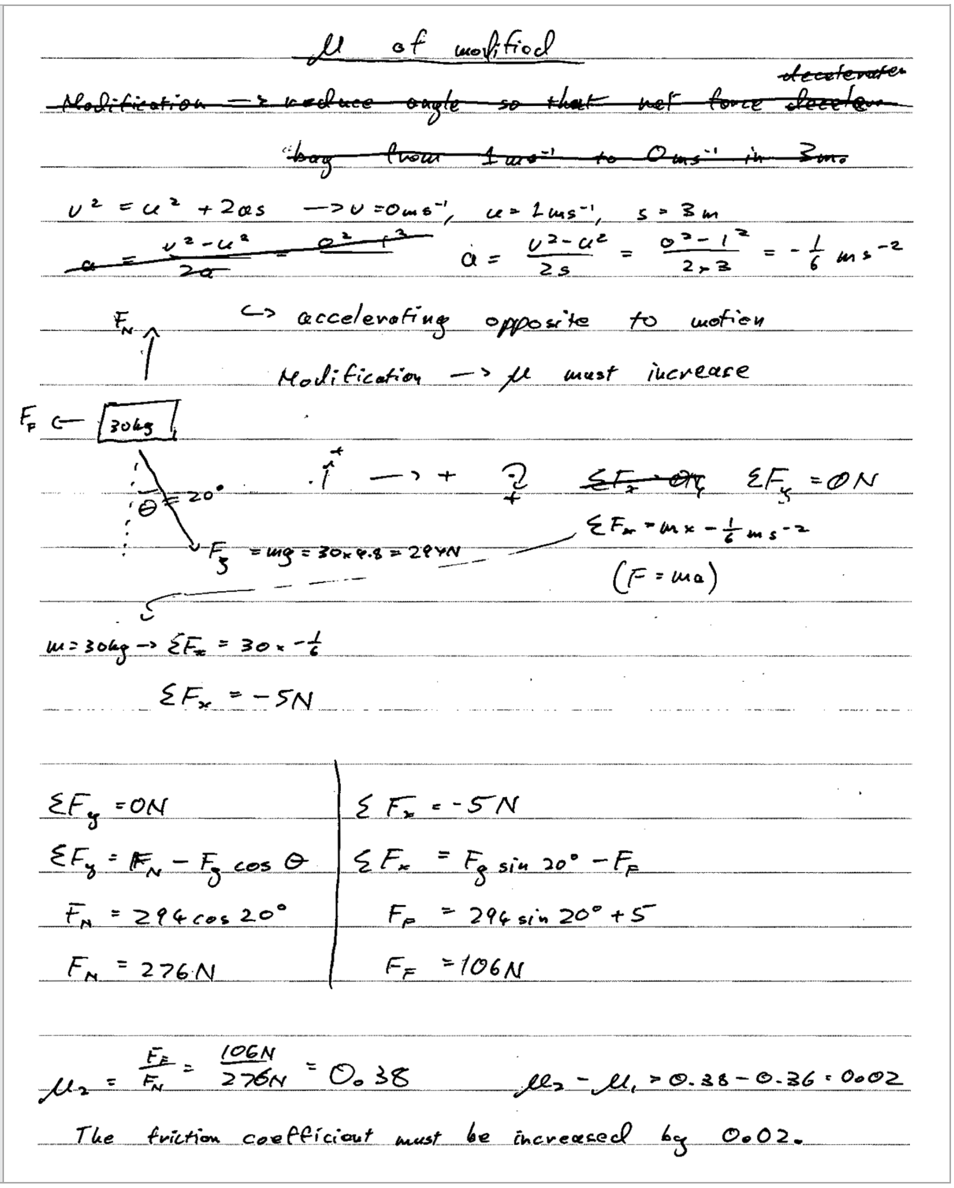
Effective student responses included:

- a well-structured solution that clearly indicated the coefficient of kinetic friction and the force of friction and force normal for the bag on the chute with cushion
- the deceleration and force of friction required to stop the bag when the cushion is removed
- the coefficient of kinetic friction for the modified luggage chute without the cushion
- the difference between the coefficients of friction being provided to two decimal places as the solution.

This sample has been included to:

- illustrate a high-level response that clearly details the calculations used to determine the solution to two decimal places.

High-level response (9 marks)	**QUESTION 22 (9 marks)** A bag slides for 3 seconds at a constant velocity of 1 m/s down a 20° luggage chute until it impacts with a cushioning device as shown in the diagram. If the cushioning device is removed, the surface of the chute will need to be modified to slow the bag to a stop at the base of the chute.  Not drawn to scale Determine the difference between the coefficients of friction for the modified chute and the original with the cushioning device. Answer to two decimal places.  μ of original → ~~No~~ Net force of 0N (no acceleration) ↳ Angle of repose is 20° ↳ $\mu_1 = \tan 20°$ $\mu_1 = 0.36$

μ of modified

~~Modification → reduce angle so that net force decelerate bag from 1 ms⁻¹ to 0 ms⁻¹ in 3 m~~

$v^2 = u^2 + 2as \rightarrow v = 0\ ms^{-1},\ u = 1\ ms^{-1},\ s = 3\ m$

~~$a = \frac{v^2 - u^2}{2a} = \frac{0^2 - 1^2}{}$~~ $a = \frac{v^2 - u^2}{2s} = \frac{0^2 - 1^2}{2 \times 3} = -\frac{1}{6}\ ms^{-2}$

→ accelerating opposite to motion

Modification → μ must increase

↑ → + ~~$\Sigma F_x = 0$~~ $\Sigma F_y = 0N$

$\Sigma F_x = m \times -\frac{1}{6}\ ms^{-2}$ $(F = ma)$

$m = 30kg \rightarrow \Sigma F_x = 30 \times -\frac{1}{6}$

$\Sigma F_x = -5N$

$\Sigma F_y = 0N$ | $\Sigma F_x = -5N$
$\Sigma F_y = F_N - F_g \cos\theta$ | $\Sigma F_x = F_g \sin 20° - F_F$
$F_N = 294 \cos 20°$ | $F_F = 294 \sin 20° + 5$
$F_N = 276N$ | $F_F = 106N$

$\mu_2 = \frac{F_F}{F_N} = \frac{106N}{276N} = 0.38$ $\mu_2 - \mu_1 = 0.38 - 0.36 = 0.02$

The friction coefficient must be increased by 0.02.

Practices to strengthen

It is recommended that when preparing students for external assessment, teachers consider:

- providing more opportunities for students to engage with complex unfamiliar situations that require an in-depth analysis of problems and information (Objective 3) to synthesise information and ideas to predict solutions (Objective 5). It is recommended that students examine or consider a range of Unit 4 subject matter in order to explain and interpret it, for the purpose of finding meaning or relationships and identifying patterns, similarities and differences. This will assist students as they answer questions that require detailed explanations to make an idea or situation plain or clear by describing it using relevant and succinct information
- further practise to understand what is required to accurately respond, as students at times overlooked key pieces of information in the questions. This led students to provide an incorrect or incomplete response or solution to some questions, e.g. Question 15 required an explanation for why an engineer would recommend solar-powered water pumps for crop irrigation for a community in a developing country. A number of students explained at length why wind-powered water pumps may not be suitable, which did not provide a suitably

structured explanation for the engineer’s the decision to recommend solar-powered water pumps

- further development and application of knowledge of Unit 4 Topic 2 subject matter. In particular, students should have an in-depth knowledge of stress–strain diagrams, the lead–tin thermal-equilibrium phase diagram, and microstructures of the steel and cast iron portions of an iron–carbon phase diagram. Students should recognise the industrial uses for carbon steels and that the chemical composition of these materials contributes to their properties and therefore their usability
- providing opportunities that contribute to student in-depth understanding of Unit 4 Topic 1 mechanics concepts and principles to support the appropriate application of formula in a range of simple familiar, complex familiar and complex unfamiliar engineering situations in relation to machines and mechanisms.