T Level Technical Qualification in Design and Development for Engineering and Manufacturing - Mechanical Engineering

Centre Standardisation Materials

Version 1.0
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For external use

Contents

Version and date	Change detail	Section
1.0 April 2024	Publication of version	n/a

Introduction

Mechanical Engineering (8714-31) (321)

These standardisation materials have been produced to support centre assessors when marking the Occupational Specialism assessment.

The materials are produced to support staff in the process of marking, including how to effectively use marking grids to mark using assessment themes.

The Occupational Specialism assessments for the T Level in Design and Development for Engineering and Manufacturing are externally set summative assessments which are internally marked by assessors. It is the centre's responsibility to ensure candidate's work is marked in a standard way across the centre, using the specified marking grids, in order to rank performance on a single mark scale.

The marking materials must be considered alongside the Technical Qualification Occupational Specialism assessment guide.

It is recommended that all assessors, including any unlikely to mark, are included in early discussions around the use of the marking grids, as all assessors should understand the basis of marking. This is because it could shape their teaching by helping candidates practise, bringing their skills and knowledge together to complete a problem, and helping them learn to explain and justify their choices in terms of subject knowledge in preparation for summative assessment.

Assessors must study the Technical Qualification Occupational Specialism assessment guide which provides detailed information about the assessment themes and the marking grids, to ensure they are clear about the different assessment themes and how they may show up in evidence across the range of tasks.

If there is more than one assessor carrying out marking at the centre, this process should be carried out as part of a group activity to ensure markers are clear and in agreement about what sorts of evidence are relevant for assessment and which assessment theme they fit into.

The following materials should form the basis for pre-standardisation and discussion could take place using evidence from trial runs/formative assessment activities. Standardisation should also take place using the evidence from the actual assignment set for that year, so along with utilising this tool, please ensure activities surrounding the live assignment also take place.

Thank you for accessing these support materials. Please note that the Practical Observation form has been updated since the publication of these materials. The Practical Observation form included in the live assessment materials is the version that must be used when assessing the Occupational Specialism.

Support and Guidance

Please ensure you have reviewed the information and guidance available in the Occupational Specialism assessment process guide ahead of completing internal standardisation activities.

- TQ Occupational Specialism Assessment Process Guide (PDF)

The following two recordings published on the websites provide support and guidance on student evidence requirements and the application of the Occupational Specialism assessment marking grids.

- Occupational Specialism Student Evidence Requirements
- Application of the Occupational Specialism assessment Marking Grids

This pack contains and references the following material:

- Links to the assessment materials and relevant Guide Standard Exemplification Materials
    - D&D Mechanical Engineering GSEM Threshold Competence
    - D&D Mechanical Engineering GSEM Distinction
- Links to the Sample Assessment Materials – Sample Assessor Pack
    - D&D Practical Assignment Mechanical Sample Assessor Pack
- A partially completed candidate record form, reflecting marking of a number of the assessment themes within this assessment

Candidate A

Assessment details

This standardisation pack has been developed to reflect the requirements of the **Mechanical Engineering – Sample** version. The assessment pack can be access on the City & Guilds website, here.

The evidence used for the exemplar marking in this pack is based on the **Guide Standard Exemplification** materials for this occupational specialism that can be located, here.

Task 1 - Design

(Assessment themes: Health and safety, Design and planning, Manufacturing, Reports)

For task 1, candidates need to produce the following pieces of evidence:

a) design specification
b) up to three annotated sketches
c) justification of the choice of one design for further development
d) justification of the selection of the materials and components
e) design calculations, including all workings
f) engineering drawings of the proposed design
g) outcomes of the virtual modelling of the proposed design, either as screen captures or printouts
h) bill of materials.

For Task 1, the following additional evidence may also be submitted:

- any notes produced of research undertaken including citation of sources and internet search history.

Task 1 - Candidate evidence

Task 1a) Design specification

Candidate evidence

Requirements from design criteria:

- The lifting device must be manually powered.
- It must reduce the effort required by workers to raise the load.
- It must be capable of lifting a cuboid box of maximum mass 15 kg.
- It must be capable of lifting a cuboid box of maximum width, depth and height each 500 mm.
- It must be capable of lifting the load from 100 mm above ground level to a height of 1 m and returning to its start position.
- The lifting platform must allow a human worker to push the box off onto a packing table.
- The lifting activity must be carried out safely.

Design specification:

Building on the requirements of the design brief, I have created the following design specification:

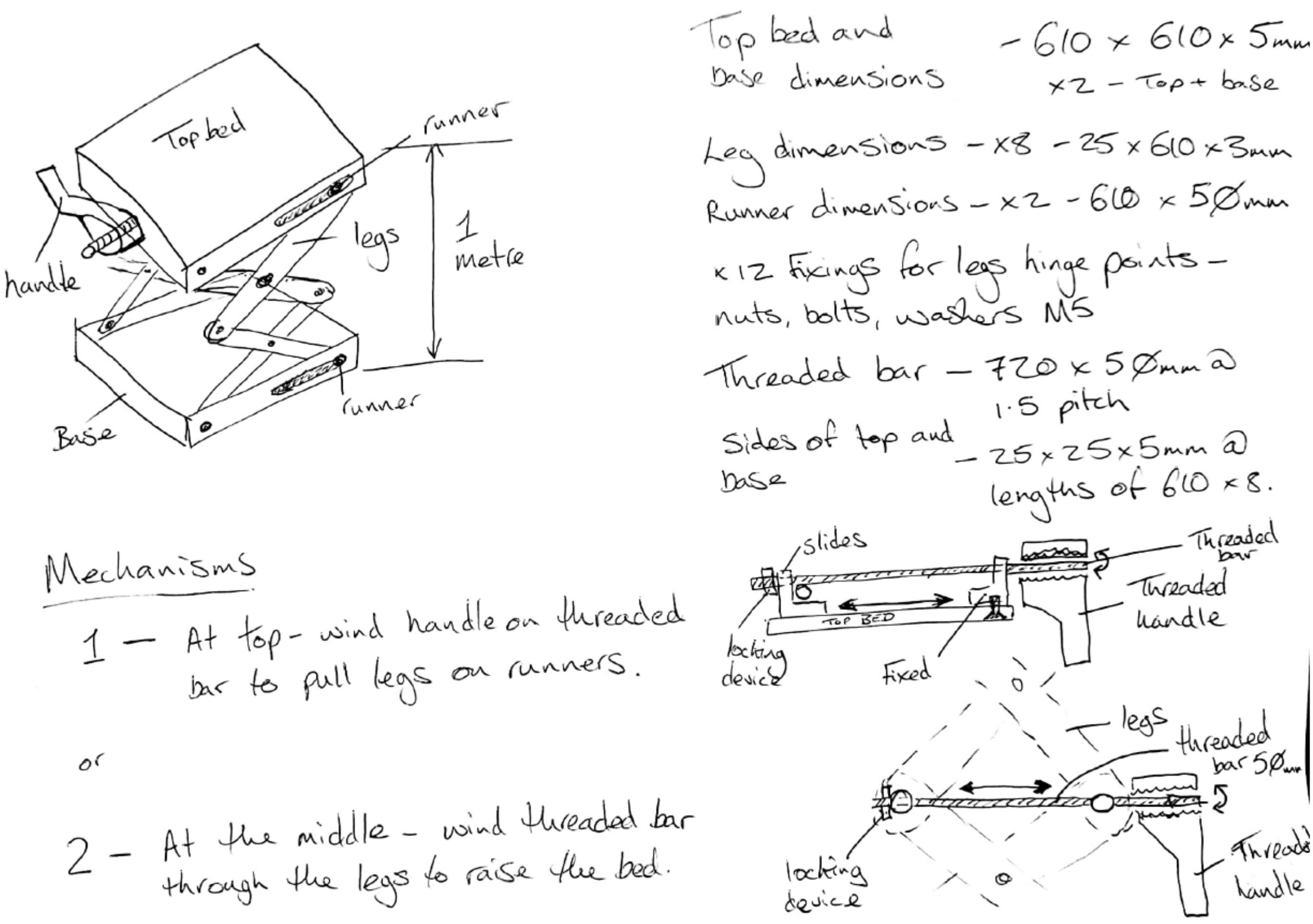
- The minimum size of the lifting platform must be 600 × 600 mm, in case loading is not accurate when the box is pushed onto it.
- The device must be capable of lifting 147 N, representing the maximum weight of the box.
- The maximum effort required to raise the load should be 107 N, as ergonomic tables show this is the maximum sustainable force by an adult.
- The device should give a mechanical advantage of at least 2.3 to lift the maximum load, based on the ergonomic tables.
- The device must be capable of lifting the load from 100 mm above ground level to a height of 1 m to allow the boxes to be loaded/unloaded, as specified in the brief.
- The device must be able to return to its start position so that it can be reused, as specified in the brief.
- The mechanism must be at a convenient height for the operator to avoid repetitive strain injuries.
- It must be lightweight so it can be manually handled by one operator.
- The platform must have no sharp edges, so that the worker using it is not cut.

- Any parts that move or rotate must be guarded or covered, to avoid finger traps causing injuries.
- The lifting platform should be made from either aluminium or steel, as these are readily available, less expensive than alternative metals, and would be resistant to minor knocks and impacts that could occur in a stores environment.
- At least 70% of the materials used in the device should be recycled or recyclable, to reduce the impact on the environment.
- The device should be made from standard-sized forms of material, to minimise the manufacturing costs incurred.

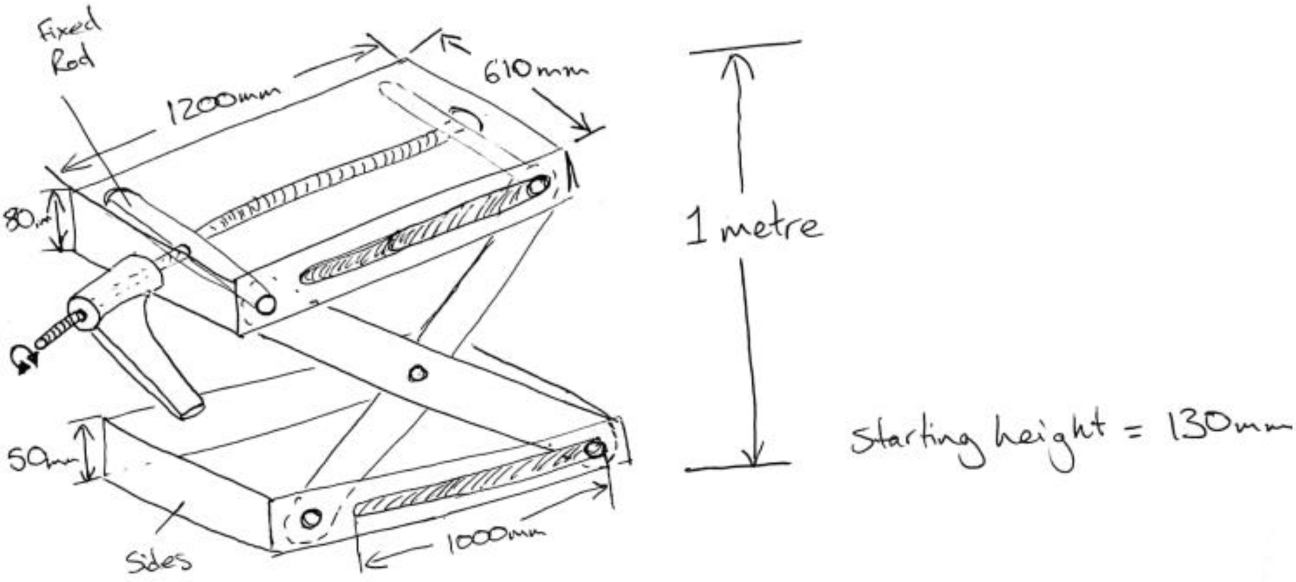
Task 1bi) Annotated sketches, block and wiring diagrams

Candidate evidence

Sketch 1



Sketch 2



Threaded bar dimension - 1.5 pitch 6mm Ø x 1500mm

Rod - 310 x 8mm Ø x 4

Legs - x4 - 1200 x 50 x 3mm

Top and base - 3mm x 1200mm x 610mm - x2

Base Sides - 3mm x 50mm x 610 - x2
3mm x 1200 x 50mm - x2

Top sides - 3 x 8 x 610 mm - x2
3 x 8 x 1200 mm x 2

Task 1c) Justification of the choice of one design for further development

Candidate evidence

Both designs have a lifting platform, which is big enough and should be able to accommodate the size and weight of the boxes. They also both have handles that will need to meet ergonomic dimensions for repetitive use. The effort required to rotate these handles will have to be considered further during the later stages to prevent repetitive strain injury.

The lift in sketch 2 is longer than required, which can become a potential health and safety hazard. The lift will also not go low enough, after initial calculations were done. For these reasons, I will not be using sketch 2.

For the lift in sketch 1, I have considered two mechanisms that would be feasible. After I did some calculations, I realised that mechanism 2 would use more material, which would affect the weight of the lifting platform. Then after some further calculations I realised that this mechanism would not allow the lift low enough to meet the specifications of the brief. Therefore mechanism 1 is the most appropriate mechanism to use for this design.

The top bed in sketch 1 would measure 610 × 610 which would accommodate sufficiently the required dimensions of the box. By using mechanism 1, the legs will be smaller. Nuts and bolts have been considered for hinges, but this may change due to the thickness of the heads and may be considered later during the manufacture of the prototype.

Task 1d) Justification of the selection of the materials and components

Candidate evidence

Material	Stainless steel
Properties	Resistance to corrosion High tensile strength Tough Good hardness Durable Resistance to temperature
Where this would be used	Base and lifting platform, handle, legs
Form of supply	Sheet and bar / rod
Ease of manufacture	Hardness means it can be difficult to cut and drill. Relatively straightforward to weld. Sheets can be fabricated into forms using standard workshop equipment.
Material positives	Durable and tough – would resist minor knocks and impacts in the stores and when moved. It has a high tensile strength, so should be able to support the boxes. Wouldn't need painting due to corrosion resistance.
Material negatives	Relatively expensive compared to other ferrous metals. High density (approximately 8000 kg/m^3) which would mean that it could be quite heavy and difficult to move around.

Material	Mild steel
Properties	High tensile strength High toughness Good weldability Prone to oxidation / rusting
Where this would be used	Base and lifting platform, handle, threaded bar
Form of supply	Sheet and bar / rod including threaded.
Ease of manufacture	Easier to cut and drill than stainless steel as not as hard. Easier to weld than stainless – could use various processes to join parts together. Easier to fabricate sheets into required forms using standard workshop equipment than for stainless steel.
Material positives	Relatively cheap compared to most metals and readily available in a wide range of standard sizes.
Material negatives	Rusts – needs painting or coating. Density approximately 7850 kg/m^3 slightly less than stainless but it could still be quite heavy and difficult to move around.

Material	Aluminium alloy
Properties	Low density Fair strength and hardness Ductile Good toughness Excellent corrosion resistance
Where this would be used	Base and lifting platform, handle
Form of supply	Sheet and bar / rod
Ease of manufacture	Easier to machine than the ferrous metals due to lower hardness. Can be difficult to weld – would need to use the TIG process. Easier to fabricate sheets into required forms using standard workshop equipment than for ferrous metals due to higher ductility and lower strength.
Material positives	Lower density (2700 kg/m^3) and good strength-to-weight ratio means compared to ferrous metals means that the design could be light weight which could make the lifting device easier to move around. Relatively easy to cut, drill and fabricate. Corrosion resistant so no finish would need to be applied to the device.
Material negatives	More expensive than ferrous metals. Can be harder than some materials to achieve a strong weld and would need to use the TIG welding process to join parts together, which requires higher skill than MIG welding.

Material	Brass
Properties	Moderate strength Corrosion resistance Aesthetically pleasing appearance
Where this would be used	Handle
Form of supply	Bar and rod
Ease of manufacture	Easier to cut, drill and turn than aluminium alloy. Can be difficult to weld – would need to use the brazing process.
Material positives	Good aesthetic appearance. Corrosion resistant so the lifting device would not need to have an applied finish. Relatively easy to turn compared to other metals.
Material negatives	Relatively expensive compared to both aluminium alloys and stainless steel. High density (8730 kg/m^3) so would add more to the weight of the device than other metals.

Considering the above, I will use mild steel for the base, lifting platform, mechanism and runner rails, as this has good strength and toughness, so would be able to lift the boxes without bending and be resistant to knocks and minor impacts which can occur in the stores area. Also, it is available in a broad range of standard sizes and is the lowest cost. It will need to be painted though, to stop rusting. For the handle I will use brass, as this is relatively easy to turn and aesthetically pleasing, although costly.

Task 1e) Design calculations

Candidate evidence

Mechanical advantage

From ergonomic tables at https://ergoweb.com/force-guidelines/:

Maximum manual lever force that can be applied = 29 lbs = 13 kg = 127.5 N

Maximum two-handed push pull force that can be sustained = 24 lbs = 10.8 kg (rounding down to avoid exceeding effort) = 105.9 N

Maximum load from box = 15 × 9.81 = 147 N

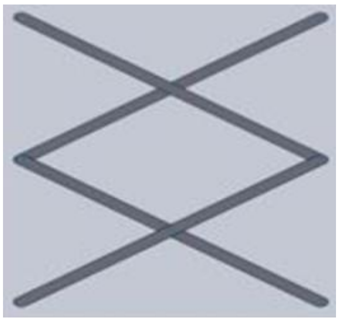
F=ma

Mechanical advantage (MA) = output force / input force = load / applied force

With a lever = 147 / 127.5 = 1.15

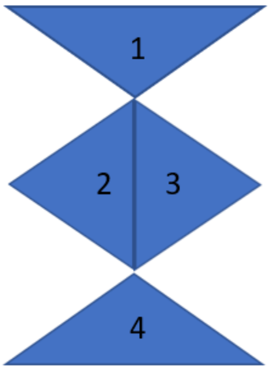
With a wheel = 147 / 105.9 = 1.38

Operating size of the scissor lift



The scissor lift forms a diamond shape which can be considered as 4 triangles. If the angle at the base is 60 degrees when fully raised, then this gives an angle in each triangle of 30 degrees.

Using trigonometry, the length of each arm of the scissor lift = 300 / cos 30 = 346 mm.



This means when fully opened out the width of the device could potentially be 346 × 4 = 1384 mm much higher than the required amount but reassuringly meeting the required height.

Mechanical advantage of the scissor lift

If the scissor lift has a pitch X_L of 3 mm, and a typical operating efficiency η of 0.3, then to raise a load of 147 N with a handle 200 mm long.

Work done on load = load × X_L = 147 × 3 = 441 N mm

Work done by effort = work done on load/ η = 441/0.3 = 1470 N mm

FE = work done by effort / X_E where X_E = 2π × 200 = 1257 mm

FE = 1470 / 1257 = 1.16 N

Mechanical advantage = load / applied force = 441 / 1.16 = 130

Risk of failure

Tensile failure

The cross-sectional area of platform = w × h = 0.003 × 1.384 = 0.0041 m^2

Stress in lifting platform due to box = F / A = 147 / 0.0041 = 36 kN / m^2

Even if the weakest material (aluminium) is used, this is significantly less than the yield stress of 90 MPa.

If the lifting arm is also made from 10 mm thick material with a width of 40 mm, then the stress in it = F / A = 147 / (0.01 × 0.04) = 3.67 kN / m^2 still significantly less than the yield stress of 90 MPa.

Risk of buckling - Maximum possible deflection of the lifting platform

$I = bh^3 / 12 = 0.51 \times 0.01^3 / 12 = 4.25 \times 10^{-8}\ m^4$

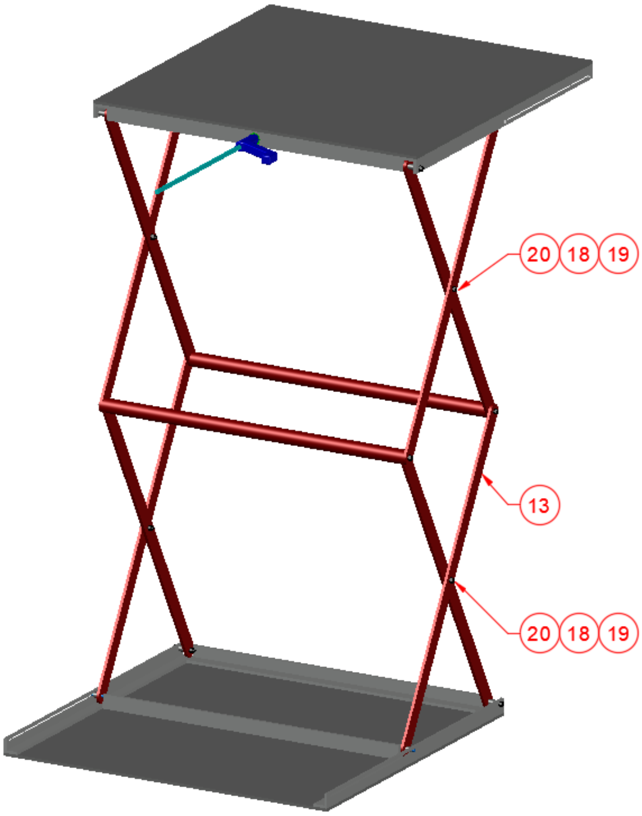
Taking the lifting platform as a cantilever beam, and assuming the maximum mass of box is loaded at the opposite edge of the lifting platform and the base is made from the material with the lowest Young's modulus (aluminium), the maximum deflection at the end of the lifting platform furthest from the arm would be:

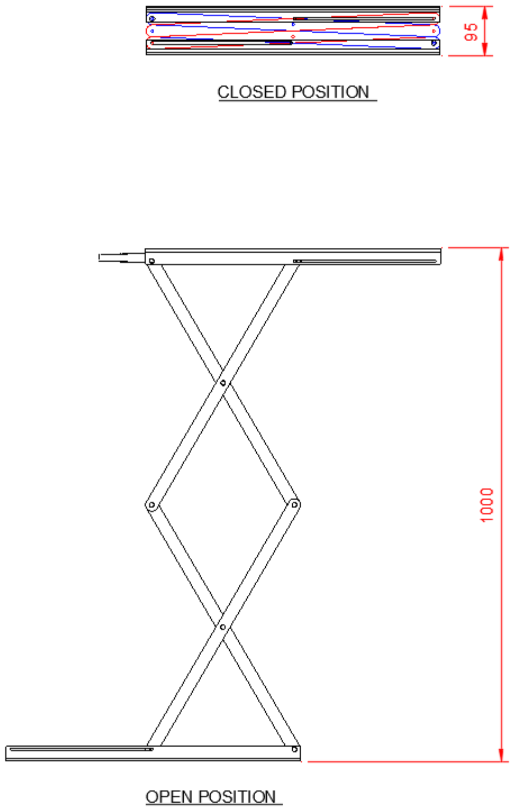
$\delta_B = F L^3 / (3 E I) = 147 \times 1^3 / (3 \times 60 \times 10^9 \times 4.25 \times 10^{-8}) = 0.019$ m or 19 mm

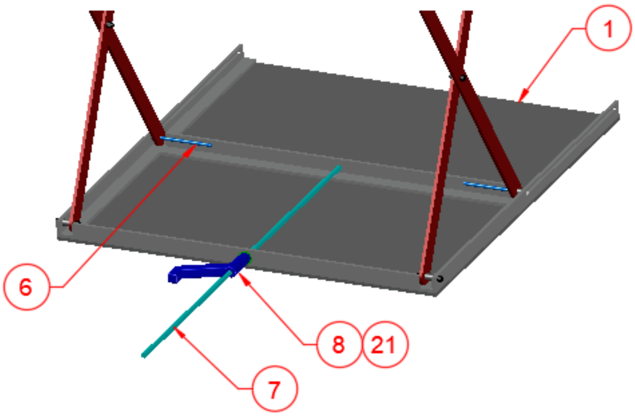
The worst case deflection of the lifting platform from this load could be 19 mm.

Task 1f) Engineering drawings

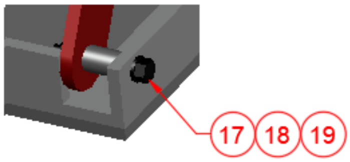
Candidate evidence



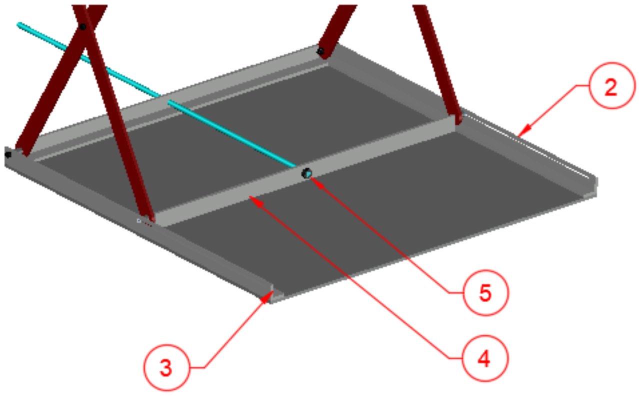




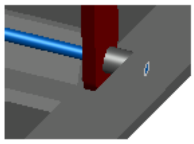
FRONT UNDERSIDE VIEW OF TOP PLATE



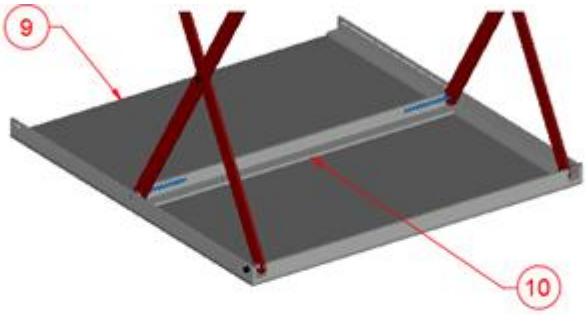
SCISSOR LEG / BRACKET
CONNECTION DETAIL 1



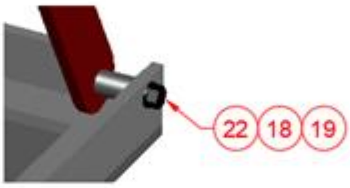
REAR UNDERSIDE VIEW OF TOP PLATE



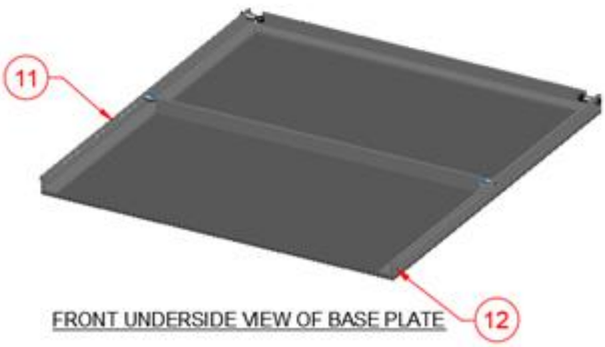
SCISSOR LEG / BRACKET
CONNECTION DETAIL 2



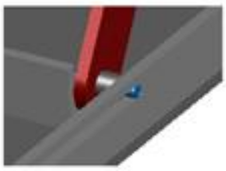
REAR UNDERSIDE VIEW OF BASE PLATE



SCISSOR LEG / BRACKET
CONNECTION DETAIL 1



FRONT UNDERSIDE VIEW OF BASE PLATE

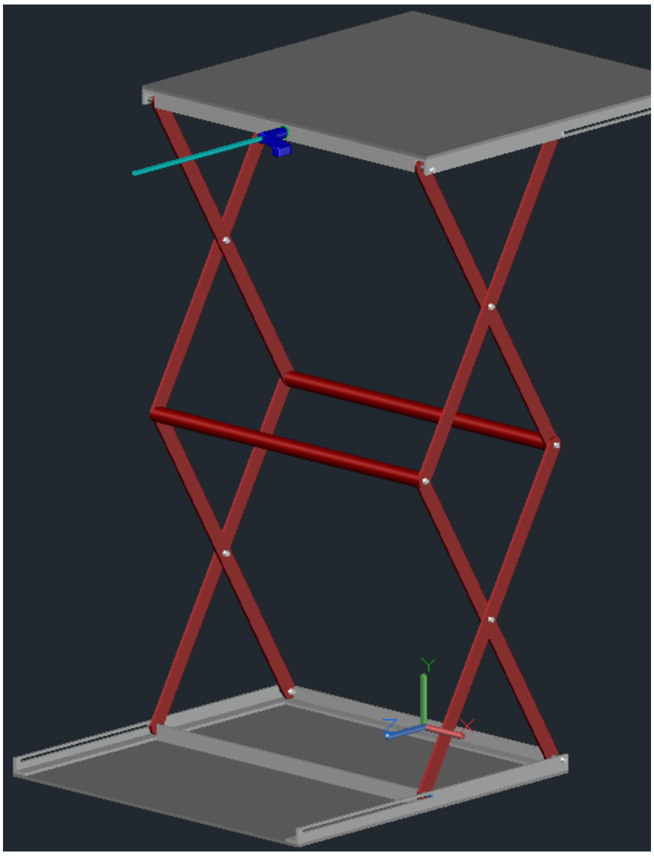
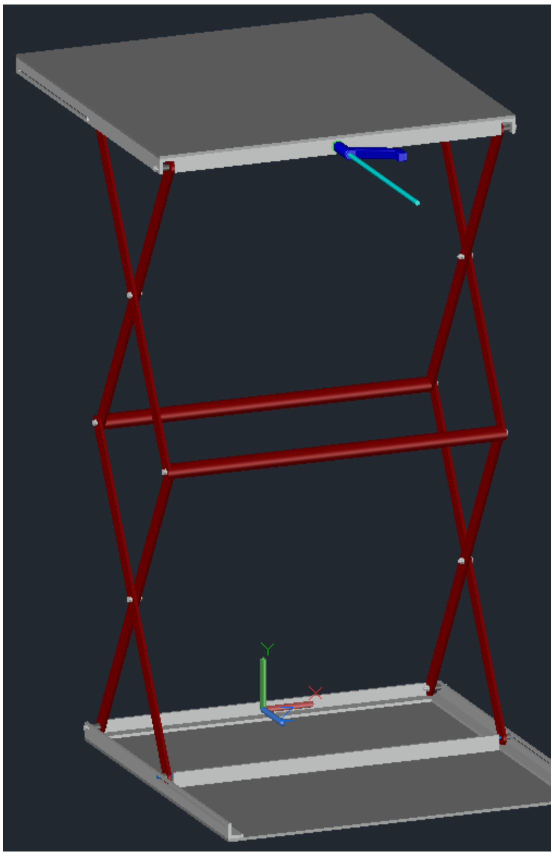
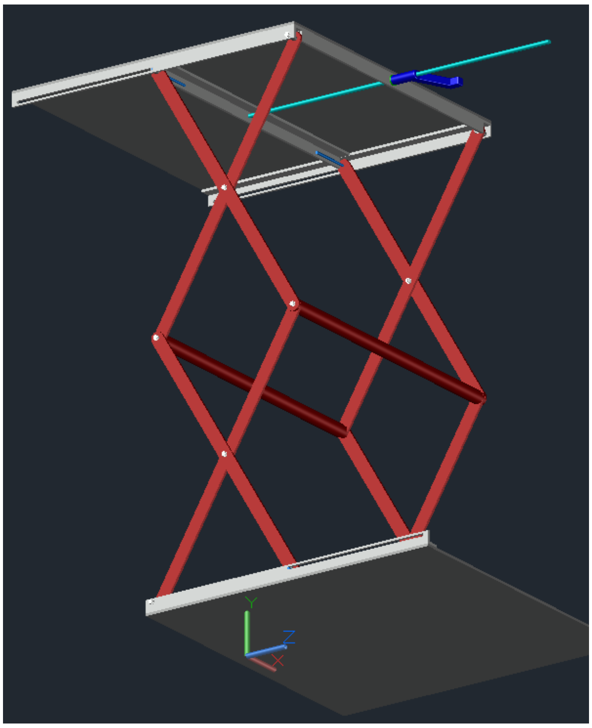
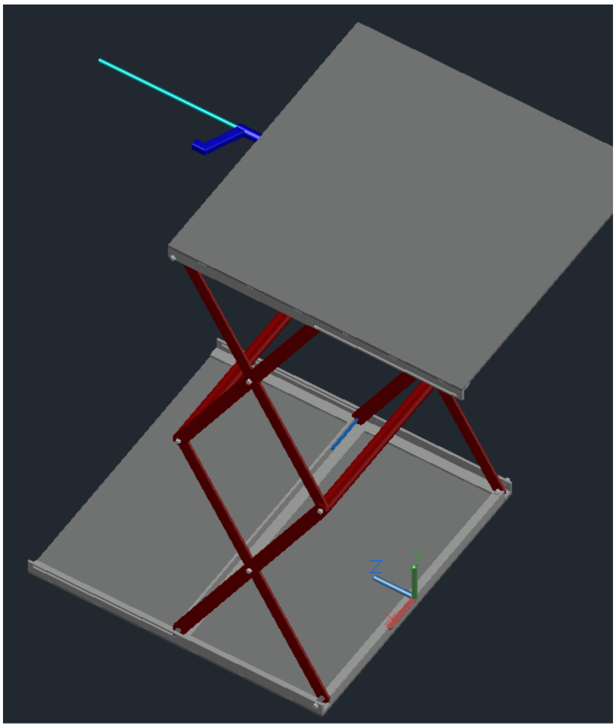


SCISSOR LEG / BRACKET
CONNECTION DETAIL 2

PARTS LIST		
PART No.	DESCRIPTION	QUANTITY
1	TOP PLATE 600 x 600 x 5 THICK	1
2	TOP PLATE - SIDE BRACKET - RH - 25 x 25 x 5 THICK	1
3	TOP PLATE - SIDE BRACKET - LH - 25 x 25 x 5 THICK	1
4	TOP PLATE - SLIDE BRACKET - 25 x 25 x 5 THICK	1
5	WELDED NUT - M8	2
6	RUNNER RAILS - M5 x 100 LONG	4
7	STUDDING STAINLESS STEEL - M8 x 650 LONG	1
8	HANDLE - M8	1
9	BASE PLATE 585 x 585 x 5 THICK	1
10	BASE PLATE - SLIDE BRACKET - 25 x 25 x 5 THICK	1
11	BASE PLATE - SIDE BRACKET - LH - 25 x 25 x 5 THICK	1
12	BASE PLATE - SIDE BRACKET - RH - 25 x 25 x 5 THICK	1
13	SCISSOR LEG - 600 x 25 x 5 THICK	8
14	SCISSOR LEG BRACE - Ø25 x 550 LONG	2
15	SPACER - Ø10 x 10 LONG	4
16	SPACER - Ø10 x 15 LONG	4
17	BOLT - M5 x 35 LONG	2
18	WASHER - M5	16
19	NUT - M5	12

Task 1g) Outcomes of the virtual modelling of the proposed design

Candidate evidence

Task 1h) Bill of materials

Candidate evidence

I have compiled the following Bill of Materials. This outlines all of the materials and components that will be required to make the lift. The dimensions of each part are in the engineering drawings presented in part 1f.

Component	Material	Quantity	Reason
Lifting platform and base	Mild steel sheet, 3 mm thick, 610 × 610 mm	2	Stronger than aluminium (tensile strength 400 MPa compared to 90 MPa) but also higher density (7 g/cm^3 compared to 2.7 g/cm^3) so heavier if the same size. Costs less than other metals and readily available. Recyclable. Cut from sheet of standard thickness.
Rail runners	Stainless steel rod, 5 mm diameter × 610 m	4	Chosen as can be welded with ease to the mechanism.
Mechanism	Stainless steel M8 × 650mm long. 1.5 pitch, 1 m maximum raise	1	Strong material for the thread. Won't corrode, which could otherwise cause the device to jam over time.
Legs	Mild steel, 2 mm thick, 25 mm wide and 300 mm long	8	Cut from sheet of standard thickness. Reasons as above.
Handle	Stainless steel, 10 mm diameter × 200 mm long with internal thread	1	Strong so will not bend easily. Aesthetically pleasing. Resistant to corrosion from handling.
Knob for handle	Brass	1	Bought-in item as easier than making. Aesthetically pleasing.

Task 2 – Manufacture and test

(Assessment themes: Health and safety, Manufacturing, Reports)

For task 2, candidates need to produce the following pieces of evidence:

a) risk assessment

b) manufactured prototype

c) test records for the operation of the prototype.

- Assessor observation of:
  - manufacturing
  - testing the prototype.

Photographic evidence which shows:

- the step-by-step construction of the lifting device (photographs 1-6)
- the fit and relative orientation of the mechanical parts (photographs 6-11)
- the final prototype (photographs 7-11)

The following supporting evidence has not been included for this version of the guide standard exemplification materials:

Video evidence which shows:

- functionality of the prototype.

Task 2 - Candidate evidence

Task 2a) Risk assessment

Candidate evidence

Hazard(s)	Risk(s)	Control measures	Risk rating	
			Likelihood	Severity
Working area	Slips, trips and falls	Ensure area is clean and tidy	3	1
Using a pillar drill during the manufacture of the prototype	Entanglement Ejected Wood chips, splinters Workpiece not held securely	Use machine guards Wear safety glasses Tie back hair and ties Use machine vice to secure work	2	2
Using a hacksaw during the manufacture of the prototype	Sharp edges on cut material Entanglement Workpiece not held securely	Use sufficient blade on the hacksaw Wear safety glasses Tie back hair and ties	1	3
Broken / poor handles on the tools	Stabbing or slipping with hand tools Inaccurate cutting lengths etc.	Visual safety inspection before use	3	2
Fire	Burns	Dispose of flammable waste Fire alarms and procedures	2	4
Using tap and die and hand tools during the manufacture of the prototype	Sharp edges on cut material	Wear gloves	2	1

Likelihood		Severity	
1	Very unlikely to happen	1	Minor injury
2	Unlikely to happen	2	Major injury
3	Possible to happen	3	Loss of limb
4	Likely to happen	4	Death of an individual
5	Very likely to happen	5	Multiple deaths

Task 2b) Manufacture of the prototype

Candidate evidence

I have decided to make the prototype out of wood as a substitute material as this cheaper and assessable to all centres (with and without metal fabrication department). The wood can demonstrate the required mechanical principles but with less strength and durability; therefore, as a prototype **only**, this allows for modifications and demonstration of feasibility. For the actual production of the lifting platform, steel should still be used.

I produced a scaled down version (1:2 ratio) and achieved a demonstration of the operation with scaled weight to match.

Photograph 1 shows the candidate's tool selection along with some components of the prototype. These are not neatly laid out, for example the screws are scattered and do not look as if they are counted to the correct quantity.

Photograph 2 shows the markings and assembly process of the prototype. The annotations are limited and only the location of the components is labelled. No measurement annotations have been added.

Photograph 3 shows the sides for the runner rails marked up. The lengths of the rails are not accurately cut (negotiable +/- 1-2 mm). The markings for the holes for the runners are missing and the level of detail is limited.

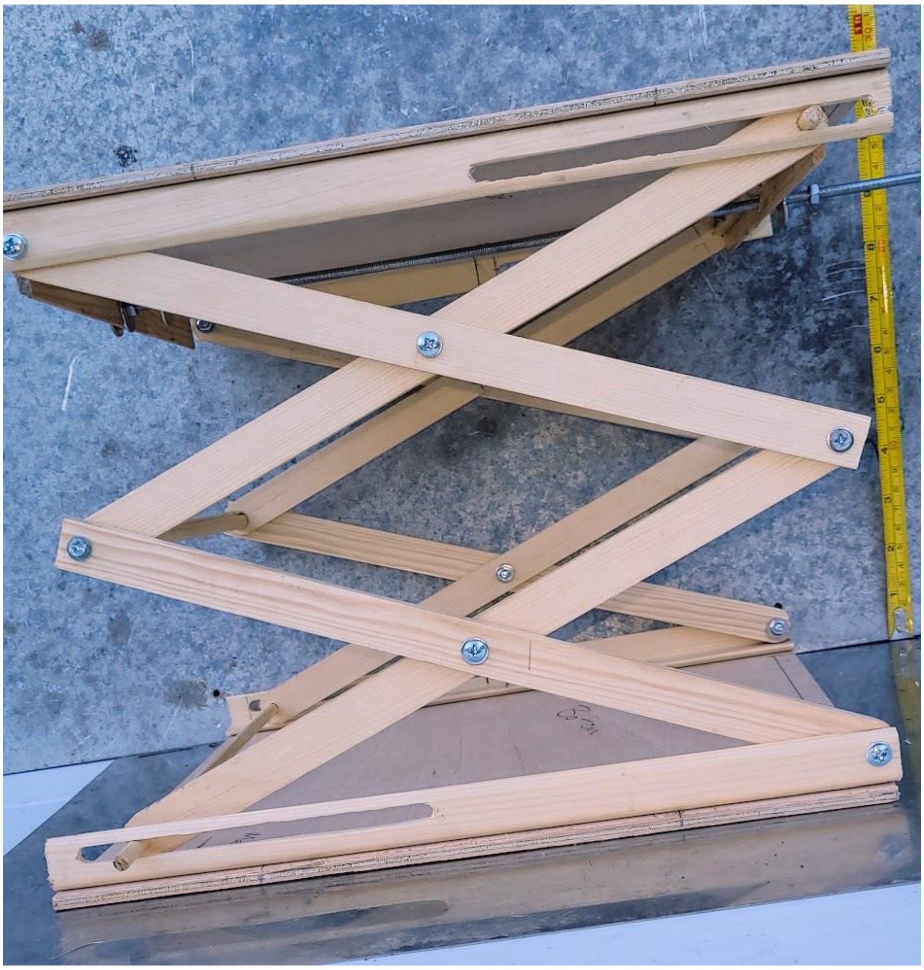
Photographs 4 and 5 show the marking out and the cut pieces. The marking is not very accurate and this resulted in the cutting being 1-2 mm short of the required length of 310 mm.

Photograph 6 shows the candidate's progression of building the prototype.

Photograph 7 shows the lifting platform at its lowest height of 50 mm, which meets the scaled dimensions required.

Photographs 8 and 9 show the platform lift at the halfway point. The lift is functional and can be raised and lowered as planned using the threaded bar mechanism.

Some of the cut legs of the scissor lift are not rounded off as per the drawings of the design, but they are still functional.



Photographs 10 and 11 show the platform lift fully extended to the maximum height. This meets the required scaled height of 500 mm. When fully extended, there is an imbalance and there is a risk of the platform tipping over if the load is placed on the unsupported end of the top platform.

Practical observation form – Prototype

Assessment ID	Qualification number
8714-321	8714-31
Candidate name	**Candidate number**
Candidate A	CG12345
Centre name	**Assessment theme**
City & Guilds	Health and Safety Manufacturing

Complete the table below referring to the relevant marking grid, found in the assessment pack. **Do not** allocate marks at this stage.

Task	Notes – ***detailed, accurate and differentiating notes which identify areas of strength and weakness are necessary to distinguish between different qualities of performance and to facilitate accurate allocation of marks once all evidence has been submitted.***
Prototype	The candidate correctly marked out the base and lifting platform using a rule, scribe and pencil. These were then cut to dimension using a hacksaw along with the rail runners and bar for the mechanism. When cutting the threaded bar, a good demonstration of accuracy and care was taken not to lose or damage the thread by placing nuts on the bar, before cutting to length. Some of the edges of the legs were not rounded off and the rods were cut with minor measurement inaccuracies, which contributed to an imperfect finish. The candidate then manually drilled holes using a pillar and handheld drill for accuracy. The drilled holes were not always centrally aligned. Glue was used as a welding substitute in order to assemble the lift. The accuracy of this could have been improved by the use of a positioning jig. All work was completed safely, with the candidate wearing the appropriate PPE. The candidate implemented the control measures in their risk assessment when using all of the manufacturing processes. Although most steps were completed correctly and competently, the accuracy of some manufactured parts was limited and there were variations in the finish around the cuts and where files had been used to remove burrs or sharp edges. The position of the runner rails required a small adjustment for operation. With these modifications the prototype was functional. The motion when the platform was raised or lowered was slightly jittery. During operation of the prototype, it was discovered that the lift would move in unintended directions (horizontal rather than vertical). This was due to the runner rails being on the same side of the lift.

Assessor signature	Date
Assessor 1	03/04/2022

Task 2c - Testing

Candidate evidence

Test records

All testing was completed on a wooden substitute lift with a ratio of 1:2. All records have been converted to demonstrate the ability to meet the requirements in full dimensions.

Design criteria	How this was tested	Test outcome
The minimum size of the lifting platform must be 610 × 610 mm.	Measured with a meter rule.	Approx. 610 × 612 mm
The device must be capable of lifting 147 N.	Functional test with 15 kg box.	Pass
The maximum effort required to raise the load should be 107 N.	Not able to test but was easy to move during functional test.	
The device should give a mechanical advantage of at least 2.3 to lift the maximum load.	Design calculation.	MA > 100 Pass
The device must be capable of lifting the load from 100 mm above ground level to a height of 1 m.	Functional test with 15 kg box.	Pass
The device must be able to return to its start position so that it can be reused.	Functional test with 15 kg box.	Pass
The mechanism must be at a convenient height for the operator to avoid repetitive strain injuries.	Measured with a meter rule.	Height of handle ranged from 0.4 m to approx. 1.4 m
It must be lightweight.	Without having the metal, I cannot weigh the item, nor compare to my wood prototype.	N/A
The platform must have no sharp edges.	Silk test.	Couple of minor snags but no cuts
Any parts that move or rotate must be guarded or covered.	Visual inspection.	If a guard is added to final design will pass
At least 70% of the materials used in the device should be recycled or recyclable.	Device is all made in steel metal.	100% recyclable Pass
The device should be made from standard-sized forms of material.	Standard sizes used.	Pass

Practical observation form – Testing of the prototype

Assessment ID	Qualification number
8714-321	8714-31
Candidate name	**Candidate number**
Candidate A	CG12345
Centre name	**Assessment theme**
City & Guilds	Health and Safety Manufacturing

Complete the table below referring to the relevant marking grid, found in the assessment pack. **Do not** allocate marks at this stage.

Task	Notes – ***detailed, accurate and differentiating notes which identify areas of strength and weakness are necessary to distinguish between different qualities of performance and to facilitate accurate allocation of marks once all evidence has been submitted.***
Testing of the prototype	The candidate scaled down the lifting device to make testing feasible, all records were converted to what would be real if this was made from metal as proposed. The candidate tested starting and finishing height by winding up and down the lifting mechanism on the table with an appropriately mounted measuring tape. The candidate was provided with a box of the maximum dimensions and weight and performed an appropriate functional test. The candidate set up the device adjacent to the pre-positioned shelves provided by the centre to check starting and finishing height, however these were scaled down to match the scaling of the prototype. This was in a different location to the height testing but due to being made of wood the effort to relocate was minimal. The lifting platform was level with the entry picking shelf when positioned by the candidate. They had to exert effort to position the box as it didn't slide freely over the surface. The candidate then turned the handle to raise the box until it was slightly above the packing table, then pushed the box onto the packing table. Approximately 40 turns of the handle were required, which appeared to be relatively high effort. The accuracy of alignment was mainly determined by the number of turns from the user and appeared to be relatively good.

Assessor signature	Date
Assessor 1	03/04/2022

Task 3 – Peer review

(Assessment themes: Reports)

For task 3, candidates need to produce the following pieces of evidence:

- candidate notes on the candidate feedback record form

  The candidate notes are not included in this document as the notes will vary from candidate to candidate and are not used to inform any other task.

- peer review feedback form.

  This is supporting evidence for assessors to see what feedback the candidate received and how they used it in their review for task 4, and will not be marked.

Task 3 - Candidate evidence

Peer review feedback form

Candidate evidence

Candidate name	**Candidate number**
Candidate B	CG01234
Centre name	**Centre number**
City & Guilds	12345

Question	**Feedback**
How well does the design meet the requirements in the brief?	*I think the design is generally good. It meets most of the requirements of the brief. It can raise the box at the required height and should be able to support the weight. The runner rails are a good idea, as these would stop the lifting platform moving too far.*
How appropriate is the equipment proposed for the design?	*The equipment used seems to be generally appropriate. I don't like that the height of the handle moves up and down with the lift, as that means the user has to bend over to use it, especially when it is close to the floor. Older workers might get a bad back from bending over a lot. Also a wheel might be easier for a worker to turn than a handle.*
What are the implications to the business of the proposed design?	*It takes a while to raise and lift each box, so it might mean that less stuff gets done in the stores. But it should also mean less effort is needed for manual lifting, which means less risk of injury and time off for people who work in the stores.*
How can the design be optimised/ improved?	*I think you should include a larger threaded bar with a coarser thread leading to fewer turns of the handle, which would make it easier for the operator to use.*

Candidate name	Candidate number
Candidate B	CG012345
Centre name	**Centre number**
City & Guilds	12345

Question	Feedback
How well does the design meet the requirements in the brief?	*This is a good design overall. It lines up well with the shelf at ground level and the packing table at the higher level. I think that there needs to be a cover over the arms of the lift, as someone could put something between the arms as it is closed. That could just be a clear sheet to act as a guard.*
How appropriate is the equipment proposed for the design?	*The equipment used seems to be generally appropriate. Maybe it could be improved a bit by making it easier to push the box onto and off the platform. That could be done by having a slippery coating on the platform or by using rollers built into the platform. That would reduce the effort needed by the operator, so they wouldn't get as tired over the movement if they have to use this a lot.*
What are the implications to the business of the proposed design?	*It should make lifting things in the stores a lot easier. It will take longer to lift using the device than just lifting by hand, but because it is easier this probably means that workers can lift more over the shift. There would also be less risk of getting a bad back due to manual lifting, so workers might have less time off injured.*
How can the design be optimised/ improved?	*As above, put a cover or guard in front of the lifting arms and make the surface of the lifting platform more slippery using a coating or rollers.*

Task 4 – Evaluation and implementation

(Assessment themes: Health and safety, Design and planning, Reports)

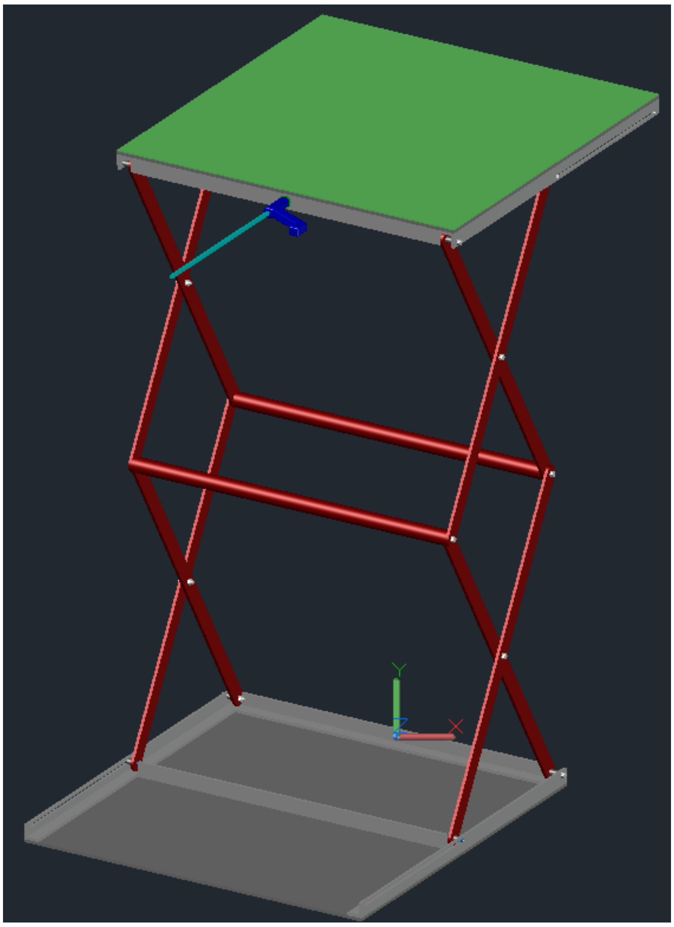
For task 4, candidates need to produce the following pieces of evidence:

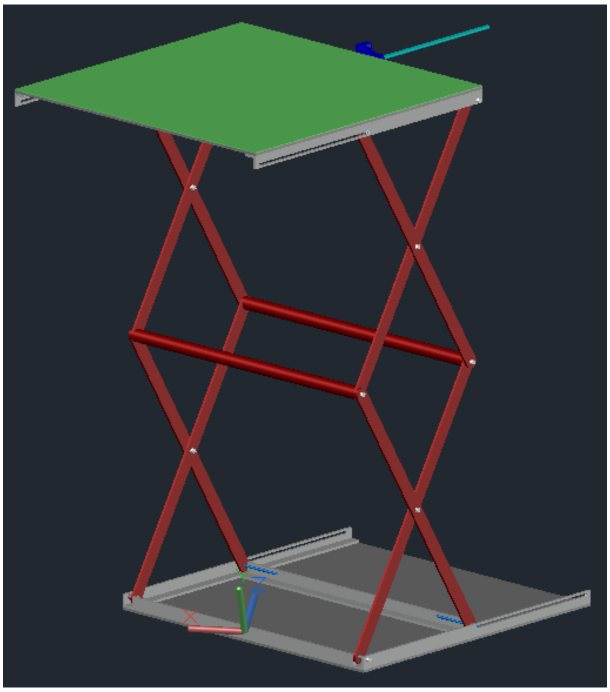
a) outcomes of virtual modelling
b) revision control document
c) evaluation and implementation report.

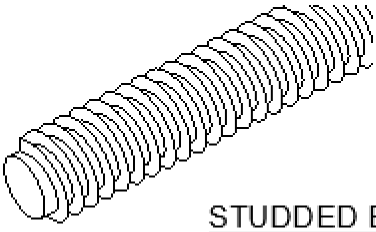
Task 4 - Candidate evidence

Task 4a) Outcomes of virtual modelling

Candidate evidence







Task 4b) Revision control document

Candidate evidence

System type	**Manually-powered mechanical lifting device**
System TAG number	A1B2C3
Department responsible for equipment	Design and Development department
System designed by:	Candidate A

Design description:
This is a device to lift boxes that arrive at ground level on a picking shelf to a height of one meter, so they can be pushed onto a packing table in the opposite direction. The boxes are cuboid in shape with a maximum side of 500 mm and a maximum weight of 15 kg. The boxes are moved off and pushed onto the packing table manually by the user. The device uses a screw mechanism which is located inside the top bed and connected to the lift arms. The user manually turns the handle to raise and lower the lifting platform, to the height and position needed. The use of a screw type of mechanism gives a big mechanical advantage, as much less effort is needed to lift the boxes than would be the case if they were lifting them by hand.
Changes to existing system:
Candidate B suggested using a larger threaded bar with coarse thread to make it easier to operate, thus creating less turns of the handle. Candidate C suggested adding a sheet of material in front of the lift arms so that no one could get fingers or clothes trapped in the mechanism when it closes down. In effect this is a guard, using a material like latex sheeting which will move freely with the lift is the most effective as a polycarbonate sheet would make the lift cumbersome. This is a good idea in principle, but in the closed position, a latex sheet will all gather up in a bundle, so I will not go ahead with this addition at this stage. This is something to consider for a possible redevelopment. This change would improve the design. I would also put a sheet of nylon on top of the lifting platform as it was difficult to push the box on and push the box back onto the table.
Changes to existing technical documentation:
The main changes that need to be made to the engineering drawings are: There needs to be extra drawings for the threaded bar and nylon sheet, which is just a rectangular piece of material. The general arrangement drawing needs to be changed with these added. The standard operating procedure (SOP) for making the nylon sheet would need to be written. The bill of materials also needs to be changed to add the threaded bar and nylon sheet. The design criteria and specification do not need to be changed, but with the changes the new design meets them better.
Comments:

Overall, I am happy with the feedback received and have acted on the main points given by each candidate as they improve the design. I have suggested changes based on these that would help my design to meet the criteria more fully.

Validation performed by:	*Assessor 1*

Prototype approved by:	*Assessor 1*

Date:	16/06/2022

Task 4c) Evaluation and implementation report

Candidate evidence

Evaluation –

Before manufacturing the prototype, I did some design calculations to ensure that it met the requirements of the brief for the mechanical advantage. I made a virtual model to ensure that the parts fitted together correctly and to simulate the loading, to give confidence that it would be able to do the task.

I mostly used scaled down functional testing to evaluate the operation of my prototype, as this gives the best indication of how well it will work when it is used by workers in the stores environment.

This involved setting up the lifting device in a simulated store area with a picking shelf and a packing table at the correct height and moving a box of the biggest possible size and weight, which was supplied by my college. I positioned the lifting platform slightly below the entry picking shelf as this made it easier to push the box onto the platform. It still required some effort as it didn't slide easily over the surface. Then I turned the handle to raise the box until it was slightly above the exit roller table. This took about 40 turns but was fairly easy as it didn't need much effort, but this was a lot of turns. I did have to bend down to turn the handle, as the handle went up and down as the lift operated. I then pushed the box onto the packing table and wound the handle the other way to lower the lifting platform back to the starting position, ready for another box.

Before the functional test, I measured the main dimensions of the lifting platform with a metre rule to make sure that the box would fit and checked that there were no sharp edges using a silk test, so there would be no risk of cutting fingers.

The testing showed that I met most of the requirements of the design specification, such as the sizes and achieving the pick-up and drop-off positions. Although I could not measure the efficiency of lifting, the force needed to do the lift didn't require much effort. Using typical figures for a scissor lift and a 200 mm handle, I calculated:

Mechanical advantage = (load × pitch / typical efficiency) / (2π × handle length) / applied force = 441 / ((147 × 1.5)/1.16) / (2π × 200) = 15.1

Overall the prototype worked well, but there are two improvements to make, the first of which came from the peer feedback:

- Candidate B suggested using a larger threaded bar with coarse thread to make it easier to operate, thus creating fewer turns of the handle.
- Put a sheet of nylon on top of the lifting platform to make the surface more slippery so it is easier to slide the box on to and off the lifting platform.

These will improve how well the design meets the design specification as the user will not have to move so much or bend over reducing the risk of repetitive strain injury and there will be less risk of the user getting trapped in the lifting mechanism.

Implementation –

In order for a third party to implement the prototype they will need the following information and documentation:

- The initial design criteria from the brief and final design specification from task 1.
- The bill of material from task 1.

- The engineering drawings for each of the individual components from task 1.
- The general assembly drawing from task 1.
- The risk assessments from task 2.
- Standard operating procedures (SOPs) or a production plan for making and assembling the parts.

It might also help if they have a copy of the virtual model so they can see what the assembled device looks like.

The main health and safety considerations for the manufacturing were the use of personal protective equipment (PPE) such as safety glasses and appropriate gloves (for handling the cut parts, except when using the lathe, where gloves would increase the risk of injury) and wearing overalls, with boots. All workers should be trained to use the processes correctly, tie back any loose clothing and hair, follow the SOPs and all the machines should be well maintained.

Guidance on the exemplar marking

Marking Grids for each assessment theme are found within the Assignment Assessor Pack and gives guidance on banding descriptors, marks available within each band as well as indicative content that provides guidance on knowledge, understanding and skills within the assessment theme.

For the purposes of these materials the Marking Grids used can be found in the Sample Assessment Materials here.

Within this standardisation pack, a partially completed CRF form has been provided that outlines how an assessor has awarded marks against the candidate evidence for a number of the assessment themes using the Marking Grid included in the Sample Assessment Materials.

For exemplification purposes, an explanation of how the marker has determined the mark to be awarded is provided, this exemplary document showing

- How the marker has first considered the marking bands available and determined within which band the evidence best fits
- Subsequently, consideration within the determined band and justification for the mark to be awarded within that band.

Candidate Record Form (CRF) – Mechanical D&D (8714-321)

Health and safety												
	Band 1				Band 2				Band 3			
	1	2	3	4	5	6	7	8	9	10	11	12
Mark 5	The evidence produced for each task, such as the design specification, risk assessment, manufacture of the prototype, assessors' observations, testing, and evaluation suggests the prototype was produced in a safe manner. The risk mitigation methods have been identified for some of the potential risks for some tools such as hacksaw and tap and die tools, but not all. Health and safety are followed during preparation and throughout tasks with most risks mitigated as they arise meaning band 1 has been exceeded. There were some considerations of health and safety as part of the evaluation and implementation report with two good attempts to suggest reducing injury, such as repetitive strain from bending and less effort required to slide boxes with a sheet of nylon. Overall, the evidence provided meets band 2 – 5 marks.											

Design and planning												
Drawings and diagrams												
	Band 1				Band 2				Band 3			
	1	2	3	4	5	6	7	8	9	10	11	12
Mark 5	Drawings/diagrams are clear and contain some of the appropriate information needed for a third party to reproduce them with inclusion of mechanisms for both designs and a brief explanation with accompanying sketch exceeding band 1 marks. However, there are some gaps to suggest methods of linkages and annotations to suggest how proposals fully meet the design specification. Engineering drawings and virtual modelling of the proposal portray some understanding of correct conventions demonstrating some good knowledge and understanding to secure the lower part of band 2. Overall, the evidence provided meets band 2 – 5 marks.											

Manufacturing									
Prototype/model									
	Band 1			Band 2			Band 3		
	1	2	3	4	5	6	7	8	9
Mark 4	The prototype model is mainly appropriate exceeding band 1 marks however, requires some minor modifications, such as the runner rails being on the same side as the lift. This is causing the lift to move in unintended directions as horizontal rather than vertical, thus, requiring some modifications to ensure the prototype meets most requirements of the design criteria. Overall, the evidence provided meets band 2 – 4 marks.								

Developing						
	Band 1		Band 2		Band 3	
	1	2	3	4	5	6

Mark 3	The selection of tools and equipment is appropriate to the task and the use of tools, equipment and processes are basic with some manufactured parts displaying variation in the finish with burrs or sharp edges. Overall, the evidence provided meets band 2 – 3 marks.

Reports						
Records						
	Band 1		**Band 2**		**Band 3**	
	1	**2**	**3**	**4**	**5**	**6**
Mark 2	Reports are completed with some inaccuracies in technical terminology. Test records portray some appropriate information and some inaccuracies in recording of test outputs and measurements. Such as the mechanical advantage calculation illustrating the operating efficiency of the prototype, drawn upon typical data that may not necessarily be accurate. Overall, the evidence provided meets band 1 – 2 marks.					

Internal assessor signature	**Date**

Total
***/90**

* Please Note that the Total Mark (90) applies to the full assignment including all Assessment Themes

Candidate B

Assessment details

This standardisation pack has been developed to reflect the requirements of the **Mechanical Engineering – Sample** version. The assessment pack can be access on the City & Guilds website, here.

The evidence used for the exemplar marking in this pack is based on the **Guide Standard Exemplification** materials for this occupational specialism that can be located, here.

Task 1 - Design

(Assessment themes: Health and safety, Design and planning, Manufacturing, Reports)

For task 1, candidates need to produce the following pieces of evidence:

a) design specification
b) up to three annotated sketches
c) justification of the choice of one design for further development
d) justification of the selection of the materials and components
e) design calculations, including all workings
f) engineering drawings of the proposed design
g) outcomes of the virtual modelling of the proposed design, either as screen captures or printouts
h) bill of materials.

For Task 1, the following additional evidence may also be submitted:

- any notes produced of research undertaken including citation of sources and internet search history.

Task 1 - Candidate evidence

Task 1a) Design specification

Candidate evidence

Requirements from design criteria:

- The lifting device must be manually powered.
- It must reduce the effort required by workers to raise the load.
- It must be capable of lifting a cuboid box of maximum mass 15 kg.
- It must be capable of lifting a cuboid box of maximum width, depth, and height each 500 mm.
- It must be capable of lifting the load from 100 mm above ground level to a height of 1 m and returning to its start position.
- The lifting platform must allow a human worker to push the box off onto a packing table.
- The lifting activity must be carried out safely.

Design specification:

Building on the requirements of the design brief, I have created the following design specification:

	Design Criteria	Reason
1.	The minimum size of the lifting platform must be at least 600 × 600 mm	To accommodate inaccurate loading when the box is pushed onto it, and also to allow the mechanism to travel to the required height.
2.	The device must be capable of lifting 147 N	Requirement of the design brief, including both the box and the lifting platform. **[See design calculations for justification]**
3.	The maximum effort required to raise the load should be 107 N	Based on the ergonomic tables as this is the maximum sustainable force by an adult. **[See design calculations for justification]**
4.	The device should give a mechanical advantage of at least 2.2 to lift the maximum load	Based on maximum effort with a lever that can be applied by an adult from the ergonomic tables. **[See design calculations for justification]**

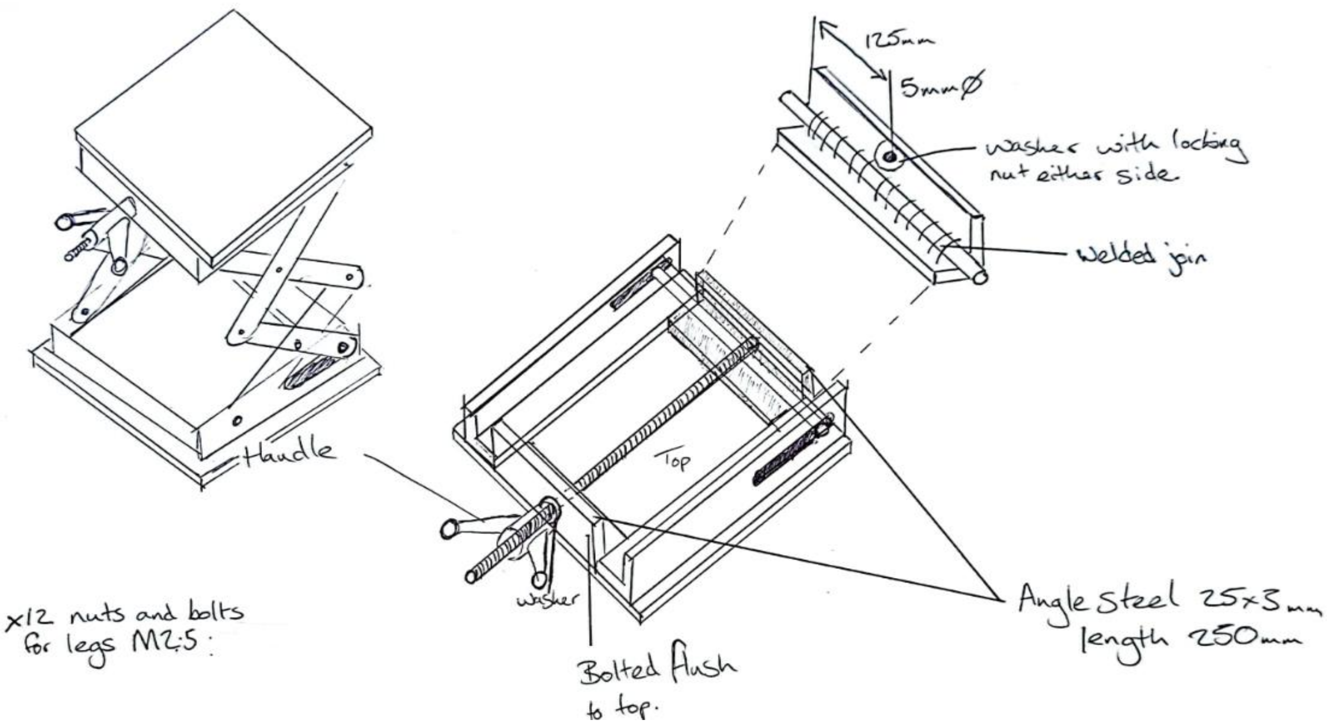
5.	The device must be capable of lifting the load from 100 mm above ground level to a height of 1 m to allow the boxes to be loaded/unloaded	Requirement of the design brief, so that it aligns with the picking shelf and the packing table.
6.	The device must be able to return to its start position	Requirement of the brief. Facilitates moving more than one box before the device is moved.
7.	The mechanism should be operated by a lever	From the ergonomic tables the user can apply a higher force to a lever than a wheel control, so if they are moving the same load the lever would feel easier.
8.	The lever must be positioned at a height between 0.5 and 1.5 m	I believe that this is a convenient height for the operator, to avoid repetitive strain injuries from bending or over extended reaching.
9.	The device must weigh less than 15 kg	So that it can be moved by one operator (as safe lifting regulations specify 15 kg as the maximum).
10.	The lifting platform should be manufactured from aluminium	If steel is used the weight of the lifting platform alone would be approximately 12.15 kg, before any other parts were added, so requirement 9 would probably not be met. Aluminium will still give the required strength but is far more lightweight. It would also be resistant to the knocks and minor impacts that could be experienced in a stores environment, particularly when being moved. **[See design calculations for justification]**
11.	The lifting platform should have a surface with low friction	To reduce the effort required by the operator to push the box into place. Friction would result in resistance to the movement and potentially generate too much heat.
12.	The platform must have no sharp edges	To reduce the risk of injury (cut fingers, skin etc) to the users and their colleagues when operating or working near to it.
13.	Any parts that move or rotate must be guarded or covered	To reduce the risk of injury (such as finger traps, entanglement etc) to the users and anybody else working nearby. Entanglement in moving parts can result in very serious injuries inclining potential loss of limbs. The device would not meet relevant health and safety standard sf not appropriately guarded.

14.	At least 70% by weight of the materials used in the device should be recycled or recyclable	To minimise impact on the environment and reduce the overall carbon footprint of the product. Using recycled and/or recyclable materials would also reduce the transportation costs of new materials.
15.	The device should be made from standard-sized forms of material	To minimise costs for obtaining or manufacturing special parts or modifying parts.

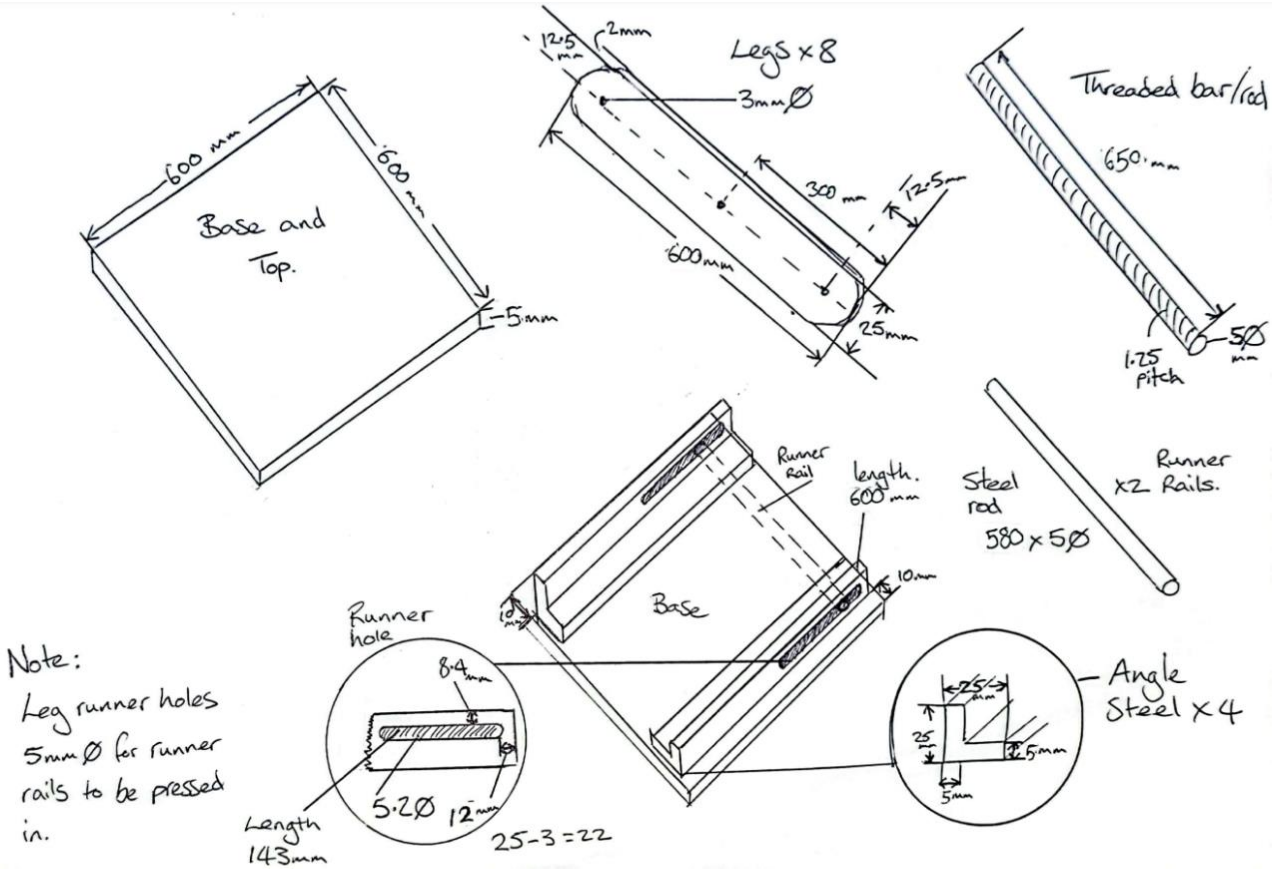
Task 1b) Annotated sketches, block and wiring diagrams

Candidate evidence

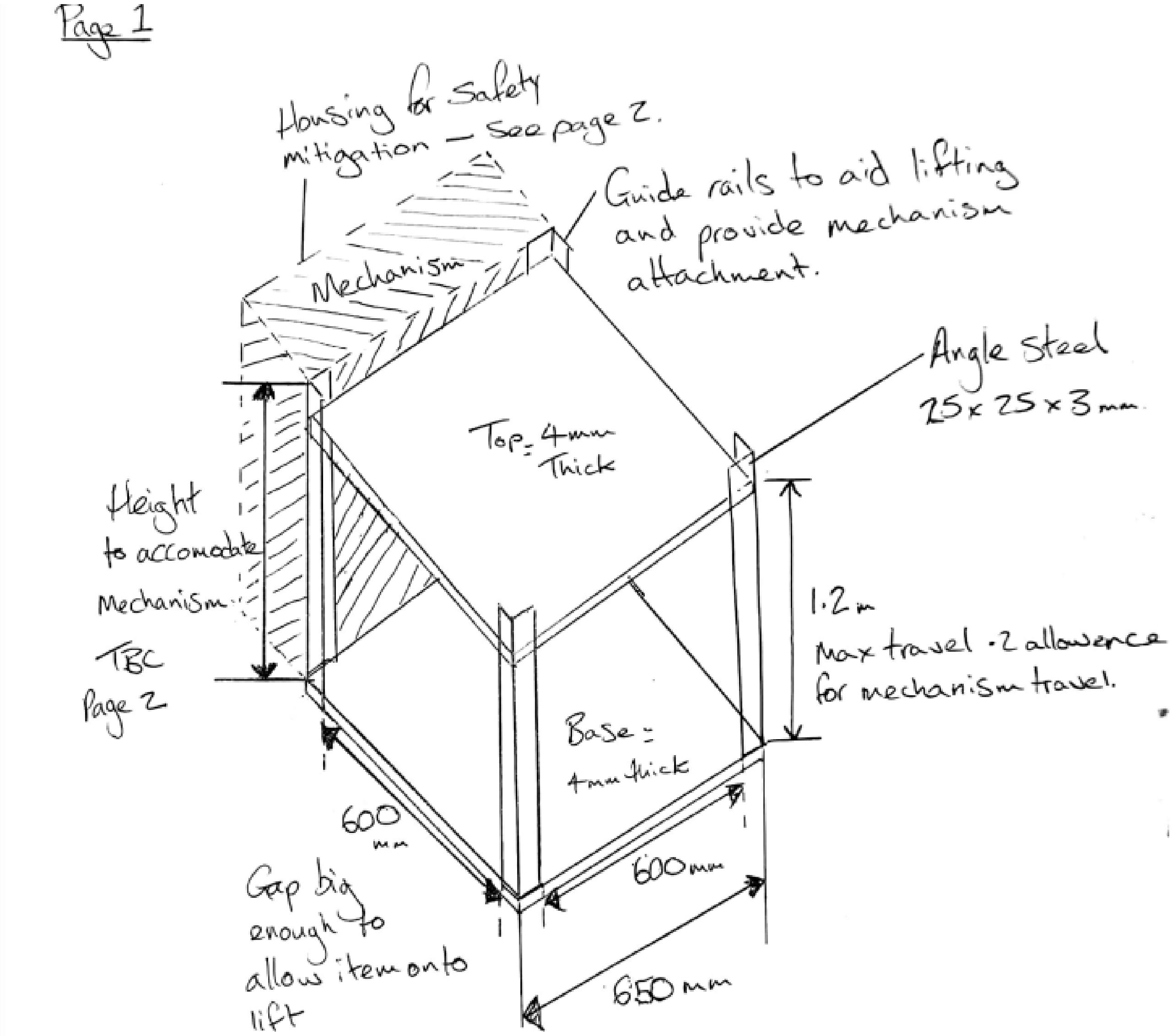
Sketch 1a



Sketch 1b

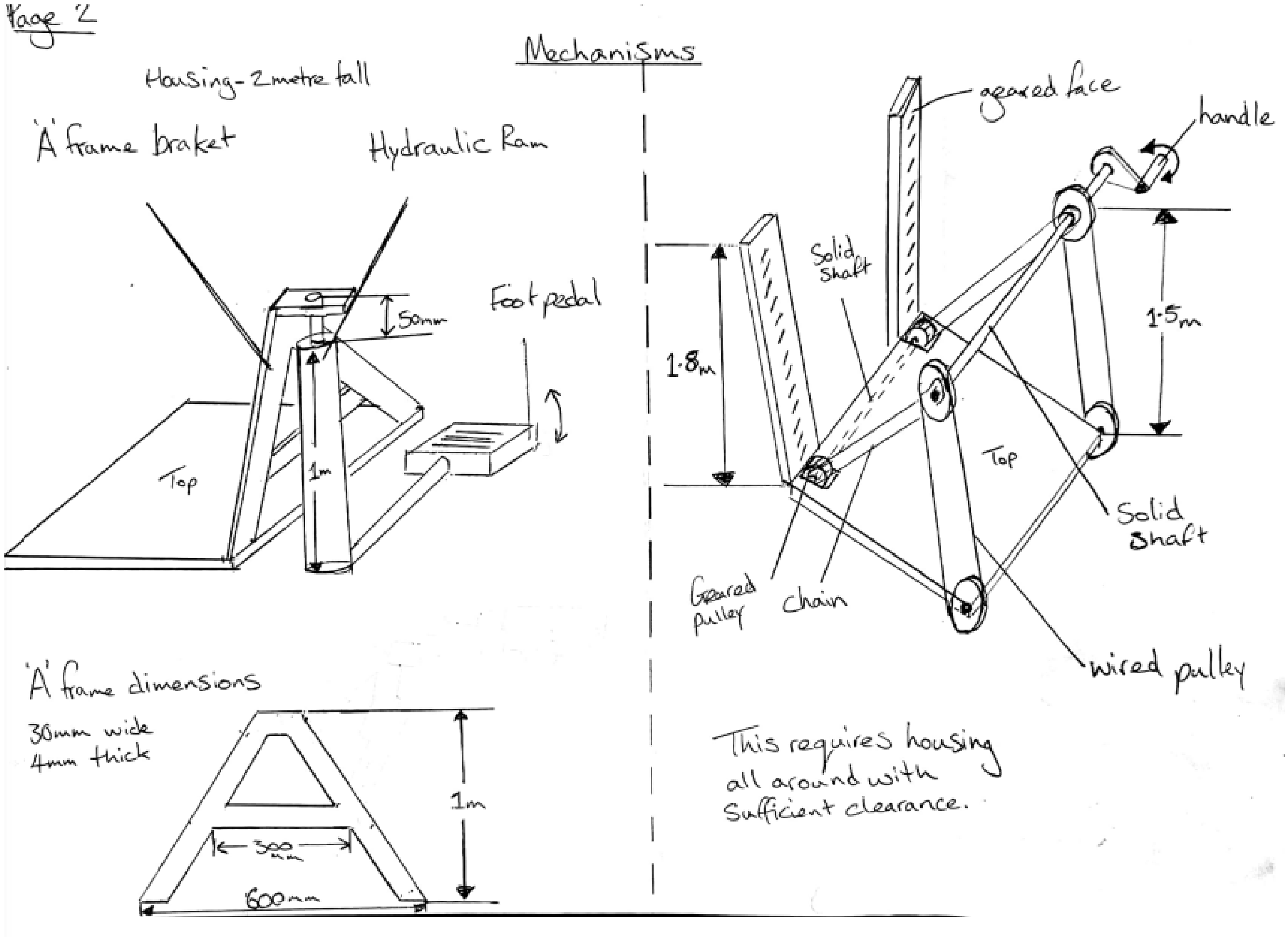


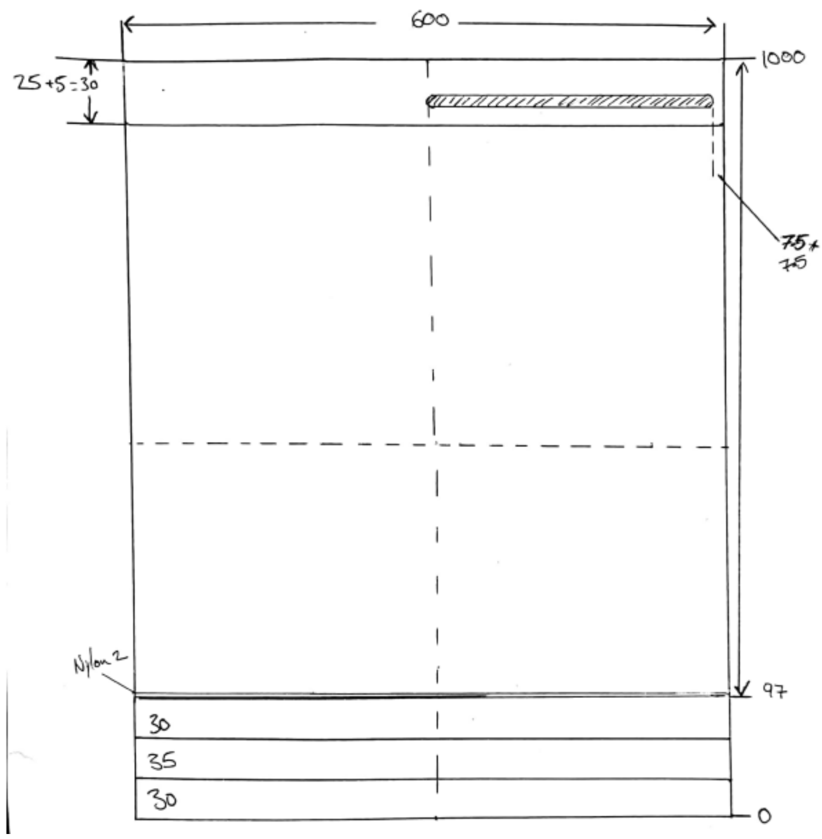
Sketch 2a



This drawing shows a general design where different lifting mechanisms can be allocated outside of the lift with a cover to prevent entrapment and injury.

Sketch 2b


Page 2
Mechanisms
Housing - 2 metre tall
'A' frame braket
Hydraulic Ram
50mm
Foot pedal
1m
Top
'A' frame dimensions
30mm wide
4mm thick
300 mm
600mm
1m
geared face
handle
Solid Shaft
1·8m
1·5m
Top
Solid Shaft
Geared pulley
Chain
wired pulley
This requires housing all around with sufficient clearance.


600
25+5=30
1000
75+75
Nylon 2
97
30
35
30
0

Rod board drawn for calculations and practical application.

The hydraulic ram would require to be mounted on a plate – extending the base of the lift. An ‘A’ frame is used to distribute the weight. A foot pedal and use of hydraulics reduces the required effort on the operator. Using pulleys seems to take up lots of space surrounding the lift and the gearing would be exposed and requires cover. Effort can be reduced by using gear reduction calculations, however this design of mechanism I feel uses up too much space. Pulleys have (mechanical advantage) MA = 4 All sketches do not show in detail a nylon sheet top, this would be used to reduce operator/human effort due to friction. Therefore, a **note** is that whatever design I finally use it must have a nylon or polycarbonate sheet attached to the top surface of the lift.

Task 1c) Justification of the choice of one design for further development

Candidate evidence

I have compared my design ideas to the design specification:

No.	Comments
1, 2, 5 & 6	Both designs have a lifting platform, which should accommodate the size and weight of the boxes, the required load, the loading and lifting heights and be able to reset to the start position.
3 & 4	All design options should meet this requirement. The pulley system (sketch 2b) has a mechanical advantage of 4, whereas both the other designs should have mechanical advantages of over 100 due to the use of leverage, meaning that they would require substantially less effort.
7 & 8	Sketch 1a could have a crank lever added, although it would operate without this so that would just add extra weight. In sketch 2b there are levers which could be located within the range specified. Sketch 1b has the advantage that the lever is in a fixed position whereas in sketch 1a the lever position will move within the range.
9	Based on the design calculations, both designs could potentially weight under 15 kg. However, to meet the guarding requirements an additional structure may be required for sketch 1a to cover the pulleys, which could increase the weight over the target value.
10, 11 & 15	All designs have an aluminium lifting platform and surfaces that have low friction, by use of a nylon surface (noted in the commentary). They could also all be made with standard sizes and forms of material.
12 & 13	As above, sketch 1b may need an additional structure to provide guarding to the moving parts. Sketch 1a would need a material cover attached to the outside of the scissor-mechanism, such as linen or nylon covered material. All designs should be able to be produced without sharp edges.
14	All designs are mainly made using aluminium or steel, both of which are recyclable. The pulleys and rope in sketch 2b would be a small proportion of the weight, but relative to sketches 1a and 2a would have a higher proportion of material that may not be recyclable. Sketch 2b may require hydraulic oil, which cannot be recycled.

My sketches lead me to think that the material of choice is steel, after evaluation I believe the use of Aluminium for the main structure and steel for the mechanism is better for weight consideration's to be met.

Although all designs could meet all of the specification requirements, my design shown in sketch 2 will not be progressed as the designs shown in sketch 1 better satisfy specification points 4, 7, 9, 13 and 14. Sketch 2b (mechanism 1) has the advantage of a fixed lever position (spec. point 8), but the hydraulic ram weighs more than the entire lift (spec. point 9) and would require hydraulic oil which means less by-weight of the mechanism could be recycled (spec. point 14). So, on balance I have decided to develop the design shown in sketch 1.

Task 1d) Justification of the selection of the materials and components

Candidate evidence

Material	Stainless steel
Properties	Resistance to corrosion Tensile strength 500-700 MPa Tough Good hardness 215 max HB Durable Resistance to temperature
Where this would be used	Runner rails, handle, mechanism and fixings.
Form of supply	Sheet and bar / rod (including threaded).
Ease of manufacture	Hardness means it can be difficult to cut and drill, taking more time and wearing out tools more quickly. Relatively straightforward to weld. Sheets can be bent using standard workshop equipment, although difficult due to high strength.
Material positives	5 mm diameter bar would be able to support tensile strength = 600 MPa (pi × r^2 × tensile strength =) 4750, substantially more than the load in spec. point 2, so would not distort during use. To support the maximum load of 147 N from spec. point 2 cross sectional area needed would be < $1mm^2$, so in practice limited only by available forms. Durable and tough – would resist minor knocks and impacts in the stores and when moved. Good hardness, so resistant to wear and tear. Would not need painting due to corrosion resistance.
Material negatives	Costs 100-200% more than mild steel, but still less expensive than aluminium alloys. High density (approximately 8 g/cm^3), which would mean that it could be quite heavy and difficult to move around. Cannot be easily welded to aluminium.

Material	Mild steel
Properties	Tensile strength 400 MPa High toughness Good hardness 130 HB Good weldability Prone to oxidation / rusting
Where this would be used	Runner rails, handle, legs and mechanism.
Form of supply	Sheet and bar / rod (including threaded).

Ease of manufacture	Easier to cut and drill than stainless steel, as not as hard. Easier to weld than stainless – could use TIG or MIG processes to join parts together. Slightly easier to bend sheets using standard workshop equipment than for stainless steel due to lower tensile strength, but more difficult than for aluminium.
Material positives	5 mm diameter runner rail would be able to support (pi × r^2 × tensile strength =) 3166 kN, substantially more than the load in spec. point 2, so would not distort during use. To support the maximum load of 147 N from spec. point 2 cross sectional area needed would also be < $1mm^2$, so in practice limited only by available forms. Relatively cheap compared to most metals and readily available in a wide range of standard sizes.
Material negatives	Rusts – needs painting or coating, which could be damaged / chipped in a store environment. Density approximately 7850 kg/m^3 slightly less than stainless but it could still be quite heavy and difficult to move around. Cannot be easily welded to aluminium.

Material	**Aluminium alloy**
Properties	Low density Tensile strength 90 MPa Fair hardness 34 HB Ductile Good toughness Excellent corrosion resistance
Where this would be used	Base and lifting platform, runner rails, handle.
Form of supply	Sheet and bar / rod (including threaded).
Ease of manufacture	Easier to machine than the ferrous metals due to lower hardness. Can be difficult to weld. – would need to use the TIG process. Easier to fabricate sheets into required forms using standard workshop equipment than for ferrous metals due to higher ductility and lower strength.
Material positives	5 mm diameter runner rails would be able to support (pi × r^2 × tensile strength =) 712 kN, still more than 25 times the load in spec. point 2, so would not distort during use. To support the maximum load of 147 N from spec. point 2 cross sectional area needed would also be < $4mm^2$, so in practice limited only by available forms. Lower density than either ferrous metal, so the weight of the device for a comparable design would be approximately 1/3 the weight if a ferrous metal was used. Good toughness so resistant to general knocks and would not need painting due to corrosion resistance. Ductility means it would be easier to form than ferrous metal options.
Material negatives	30-60% more expensive than stainless steel and 200-300% more than the cost of mild steel (although labour time would be saved during manufacture).

	Can be more challenging to achieve a strong weld, and would need to use the TIG welding process to join parts together, which requires higher skill than MIG welding.

Material	Brass
Properties	Moderate strength Corrosion resistance Aesthetically pleasing appearance Self-lubricating properties
Where this would be used	Runner rails, handle.
Form of supply	Bar and rod.
Ease of manufacture	Easier to cut, mill, drill and turn than aluminium alloy. Can be difficult to weld – would need to use the TIG process.
Material positives	Good aesthetic appearance. Corrosion resistant, so the lifting device would not need to have an applied finish. Easy to turn compared to other metals.
Material negatives	Relatively expensive compared to both aluminium alloys and stainless steel. High density (8730 kg/m^3) so would add more to the weight of the device than other metals.

Material	Nylon
Properties	Light weight Self-lubricating surface Good wear resistance
Where this would be used	Surface sheet on lifting platform.
Form of supply	Sheet.
Ease of manufacture	Easy to cut.
Material positives	Light weight. Low friction surface.
Material negatives	May not be easy to recycle.

Considering the above, I will use aluminium for the base, top, lifting arms and runner rails, as this has strength substantially above the requirement for the load in the specification, so would be able to lift the boxes without bending whilst giving the overall weight of the device approximately 1/3 of that using either mild steel or stainless steel. It has good toughness so would be resistant to knocks and minor impacts which can occur in the stores area. It is available in a broad range of standard sizes and although it costs more than either of the ferrous metals, it would be easier to manufacture due to its lower relative strength and ductility, which would reduce the time and labour cost during manufacturing. It would not need to be painted, which would further save manufacturing cost and time compared to mild steel. For the handle I will use brass, as this is relatively easy to turn and aesthetically pleasing.

I would also need a threaded bar M5 × 1.25, M3 × 5 bolts and M3 nyloc nuts. These would be made from stainless steel due to commercial availability and properties of this metal.

Task 1e) Design calculations

Candidate evidence

Mass of the lifting plate

Volume of the lifting plate = l × w × h = 61 × 61 × 6 = 22.326 cm^3

Based on density of 2.7 g cm^{-3} for Al, the mass would be 4.214 kg

Based on density of 7.85 g cm^{-3} for steel, the mass would be 12.15 kg

Based on density of 0.09 g cm^{-3} for nylon, the mass of a sheet on top of the aluminium of 60 × 60 × 0.2 cm = 720 would be 720/0.09 = 8000/1000 = 8 g

Mechanical advantage

From ergonomic tables at https://ergoweb.com/force-guidelines/:

Maximum manual lever force that can be applied = 29 lbs = 13kg = 127.5 N

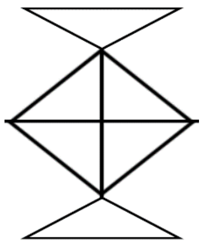
Maximum two-handed push pull force that can be sustained = 24 lbs = 10.8 kg (rounding down to avoid exceeding the maximum) = 105.9 N

Maximum load from box and lifting platform = mg = (15 + (4.214 + 0.048)) × 9.81 = 188 N

Mechanical advantage (MA) required = output force / input force = load / applied force

With a lever = 188 / 106 = 1.774

Operating size of the scissor-type lift



The scissor lift forms a diamond shape which can be considered as 4 triangles. If the angle at the base is 60 degrees when fully raised, then this gives an angle in each triangle of 30 degrees and an adjacent side of 333.3 mm (= 1000 / 3 mm).

Using trigonometry, the length of each arm of the scissor mechanism = 333.3 / cos 30 = 385 mm.

This means when fully opened out the width of the device could potentially be 1540 mm. This is beyond the required height but sufficient for use.

Mass of the device

Lifting platform, base, and nylon sheet (from above) = ((2 × 4.214) + 0.049) = 8.48 kg

Runner rails = (Ωr^2 × 150 × 2.7) × 2 = 2531 kg

Fixings 4 × M5 × 30 bolts with nuts = 4 × 0.04 (from BS 3692) + 4 × 0.01 (estimate) = 0.1 kg

Total = 8.48 + 0.65 + 9.5 + 0.1 = 18.73 kg

Mechanical advantage of the scissor- type lift

If the screw lift has a pitch X_L of 3 mm, and a typical operating efficiency η of 0.3, then to raise a load of 188 N with a handle 200 mm long.

Work done on load = load × X_L = 188 × 3 = 564 N mm

Work done by effort = work done on load/ η = 564/0.3 = 1880 N mm

FE = work done by effort / X_E where $X_E = 2\pi \times 200 = 1257$ mm

FE = 1880 / 1257 = 1.49 N

Mechanical advantage = load / applied force = 188 / 105.9 = 1.77

Risk of failure

Tensile failure

Cross sectional area of platform = 0.51 × 0.01 = 0.0051 m^2

Stress in lifting platform due to box = 147 / 0.0051 = 56.3 kN / m^2

Minimum yield stress of aluminium > 90 MPa, steel > 250 MPa dependent upon alloy, and minimum shear stress aluminium > 25 MPa, steel > 74 MPa

Assuming that the top is also made from 10 mm thick material, then its minimum width (assuming the weakest material, aluminium) would be where $90 \times 10^6 = 147 / (0.01 \times w)$; Rearranging $w = (147 / 90 \times 10^6) / 0.01 = 3.2 \times 10^{-4}$ m

and for the weakest material in shear strength (aluminium)would be $25 \times 10^6 = 147 / (0.01 \times w)$; Rearranging $w = (147 / 25 \times 10^6) / 0.01 = 5.9 \times 10^{-4}$ m

Risk of buckling - Maximum possible deflection of the lifting platform

$I = bh^3 / 12 = 0.51 \times 0.01^3 / 12 = 4.25 \times 10^{-8}\ m^4$

Taking the lifting platform as a cantilever beam (ignoring any support from the runner rails), and assuming the maximum mass of box is loaded at 260 mm from the edge with the lift (representing the maximum possible offset of the box within the platform) and the base is made from the material with the lowest Young's modulus (aluminium), the maximum deflection at the end of the lifting platform furthest from the arm would be

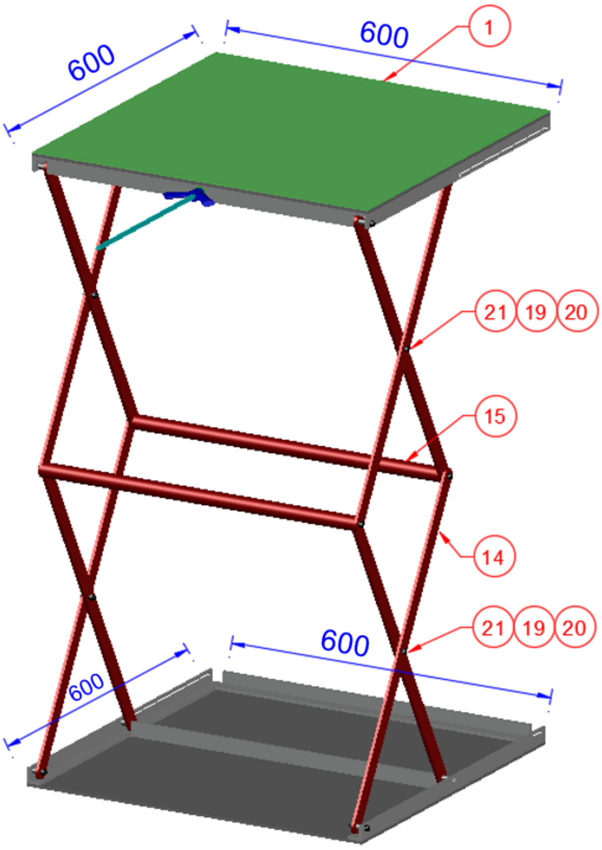
$\delta_B = (F a^3 / (3 E I)) (1 + 3 b / 2 a)$

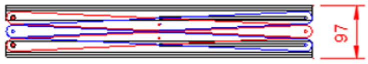
$= 147 \times 0.26^3 / (3 \times 60 \times 10^9 \times 4.25 \times 10^{-8}) (1 + 3 \times 0.25 / 2 \times 0.26) = 1.6 \times 10^{-3}$ m

I.e. the maximum possible worst case deflection of the lifting platform from this load is 1.6 mm – hence the risk of bending or buckling is in practice negligible. (If steel is used, the maximum deflection is 0.47 mm).

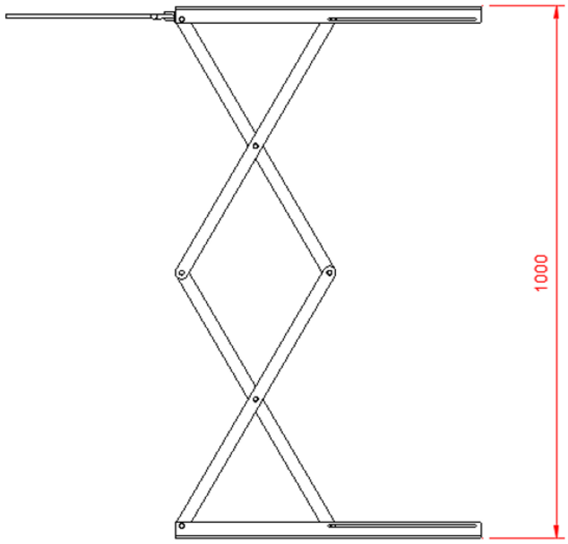
Task 1f) Engineering drawings

Candidate evidence

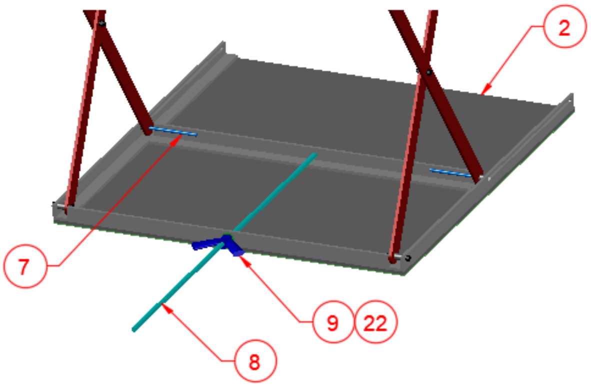




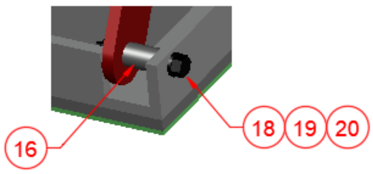
CLOSED POSITION
HEIGHT INCLUDES NYLON MAT



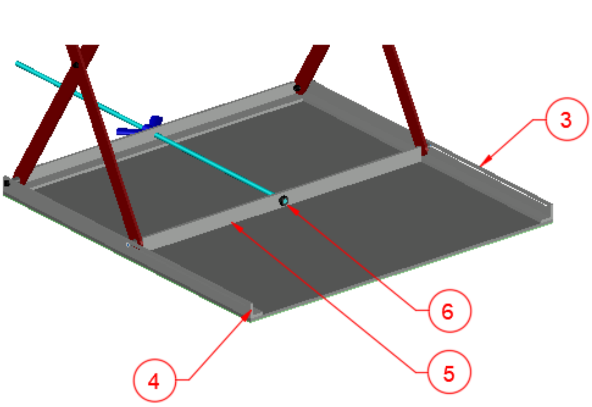
OPEN POSITION
HEIGHT INCLUDES NYLON MAT



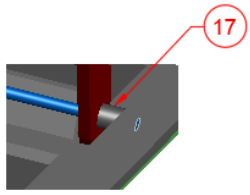
FRONT UNDERSIDE VIEW OF TOP PLATE



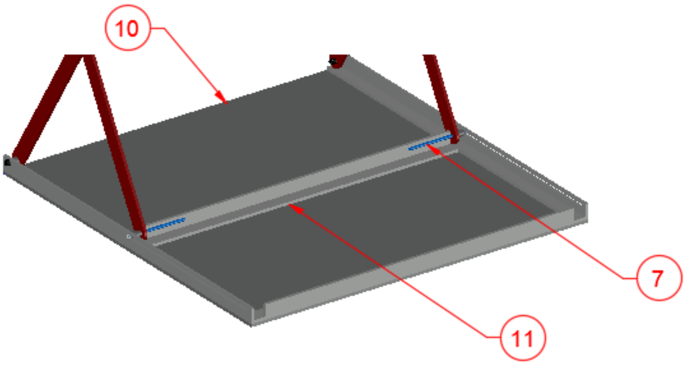
SCISSOR LEG / BRACKET
CONNECTION DETAIL 1



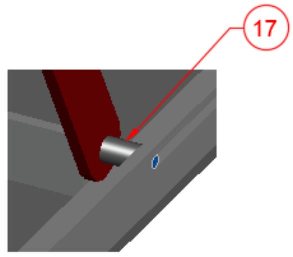
REAR UNDERSIDE VIEW OF TOP PLATE



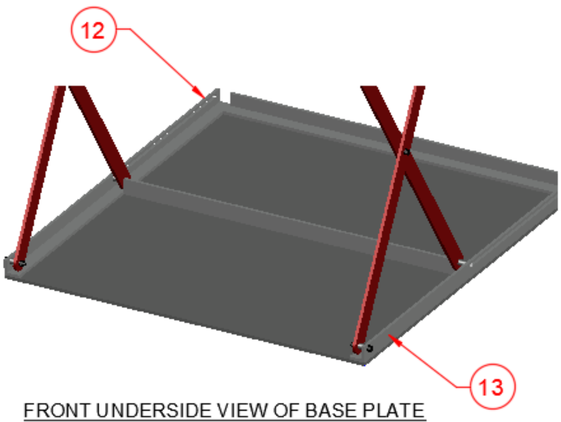
SCISSOR LEG / BRACKET
CONNECTION DETAIL 2



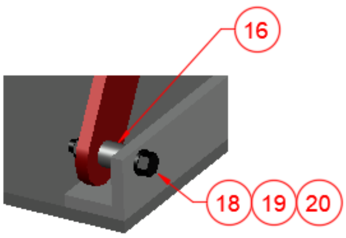
REAR UNDERSIDE VIEW OF BASE PLATE



SCISSOR LEG / BRACKET
CONNECTION DETAIL 1



FRONT UNDERSIDE VIEW OF BASE PLATE

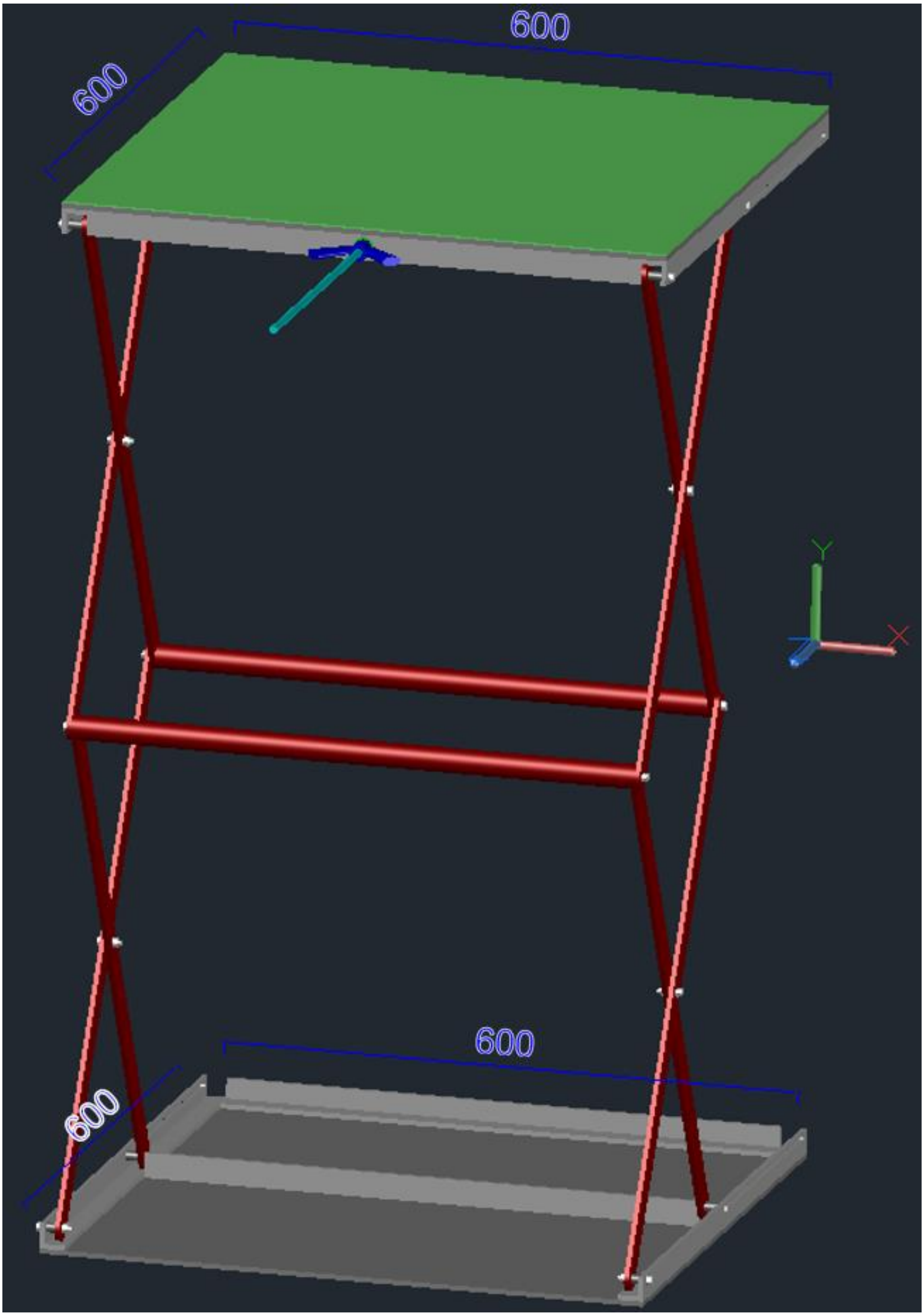


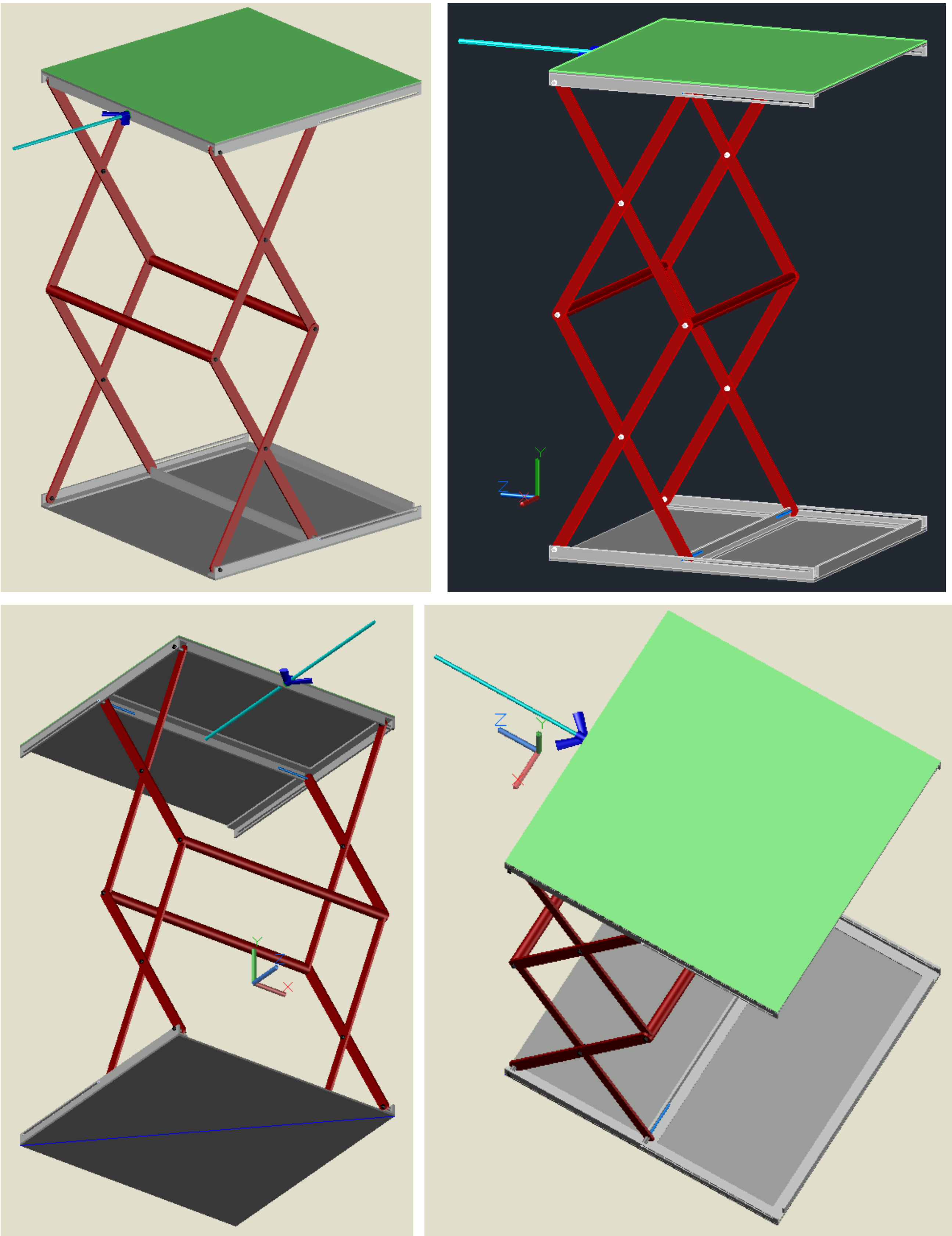
SCISSOR LEG / BRACKET
CONNECTION DETAIL 2

PARTS LIST		
PART No.	DESCRIPTION	QUANTITY
1	NYLON MAT - 600 x 600 x 2 THICK	1
2	TOP PLATE 600 x 600 x 5 THICK	1
3	TOP PLATE - SIDE BRACKET - RH - 25 x 25 x 5 THICK	1
4	TOP PLATE - SIDE BRACKET - LH - 25 x 25 x 5 THICK	1
5	TOP PLATE - SLIDE BRACKET - 25 x 25 x 5 THICK	1
6	WELDED NUT - M8	1
7	RUNNER RAILS - M5 x 100 LONG	4
8	STUDDING - M8 x 650 LONG	1
9	HANDLE - M8	1
10	BASE PLATE 600 x 600 x 5 THICK	1
11	BASE PLATE - SLIDE BRACKET - 25 x 25 x 5 THICK	1
12	BASE PLATE - SIDE BRACKET - LH - 25 x 25 x 5 THICK	1
13	BASE PLATE - SIDE BRACKET - RH - 25 x 25 x 5 THICK	1
14	SCISSOR LEG - 600 x 25 x 5 THICK	8
15	SCISSOR LEG BRACE - Ø25 x 550 LONG	2
16	SPACER - FIXED - Ø10 x 15 LONG	4
17	SPACER - SLIDER - Ø10 x 10 LONG	4
18	BOLT - M5 x 35 LONG	4
19	WASHER - M5	16
20	NUT - M5	8
21	BOLT - M5 x 20 LONG	8
22	WASHER - M8	1

Task 1g) Outcomes of the virtual modelling of the proposed design

Candidate evidence





Task 1h) Bill of materials

Candidate evidence

I have compiled the following Bill of Materials. This outlines all of the materials and components that will be required to make the lift. The dimensions of each part are in the engineering drawings presented in part 1f.

Component	Material	Size	Quantity	Reason
Lifting platform and base	Aluminium sheet	4 mm thick, 600 × 600 mm	2	Lower density than steel so lighter weight (see design calculations for justification). Cut from sheet of standard thickness.
Runner rails	Aluminium rod	5 mm diameter × 1.5 m	2	Chosen as can be TIG welded to the aluminium base plate. 5 mm as a standard size.
Lifting arms	Steel plate	4 mm thick	8	Steel for high strength as must support the full load. Cut from sheet of standard thickness.
Handle	Steel rod	10 mm diameter × 200 mm long	1	Strong and rigid (high Young's modulus) so wont bend easily.
Mechanism	Stainless Steel threaded bar	1.5 mm pitch, 1 m maximum raise	1	Bought in item as easier and cheaper than making – supporting efficient development of the prototype.
Bolts	Steel	M3 × 30 mm	8	Bought in item as easier and cheaper than making – supporting efficient development of the prototype.
Nuts	Steel	M3	8	Bought in item as easier and cheaper than making – supporting efficient development of the prototype.
Knob for handle	Brass		1	Bought in item as easier and cheaper than making – supporting efficient development of the prototype.

Task 2 – Manufacture and test

(Assessment themes: Health and safety, Manufacturing, Reports)

For task 2, candidates need to produce the following pieces of evidence:

a) risk assessment

b) manufactured prototype

c) test records for the operation of the prototype.

- Assessor observation of:
  - manufacturing
  - testing the prototype.

Photographic evidence which shows:

- the step-by-step construction of the lifting device (photographs 1-6)
- the fit and relative orientation of the mechanical parts (photographs 6-10)
- the final prototype (photographs 7-10)

The following supporting evidence has not been included for this version of the guide standard exemplification materials:

Video evidence which shows:

- functionality of the prototype.

Task 2 - Candidate evidence

2a) Risk assessment

Candidate evidence

The following risk assessments are based on the hazard and risk after the stated control measures have been applied. In the absence of the control measures, both hazards and risks would be much higher. The calculated risk rating is found by multiplying the likelihood and severity and is based on the listed control measures being in place. The risk likelihood is based on the scale shown in the table below. With the listed control measures in place, all of the risks are considered to be managed appropriately.

Hazard(s)	Risk(s)	Control measures	Risk	
			Likelihood	Severity
Working area when manufacturing and testing the prototype	Slips, trips, and falls	Ensure area is clean and tidy with no trip hazards and any spills (oil, water) mopped up. Wear safety shoes.	4	1
Pillar drill	Entanglement in the chuck	Use machine guards. Tie back hair and ties.	2	3
	Flying debris/ ejected wood chippings	Use machine guards. Wear safety glasses. Sweep debris between operations.	2	1
	Workpiece not held securely	Hold work piece in a machine vice or clamp to bed of drill with a G clamp.	2	2
Noise	Miss alarm sounds	Visual aid on the alarm, notify others that work will begin with excessive noise and to notify each other agreed safely.	3	2
	Hearing loss / impairment	Wear ear protection	3	3
Dust	Breathing impairment	Have appropriate ventilation/extraction when cutting and filling.	3	2
	Slips and falls	Ensure all dust/debris is swept away appropriately after tasks.	3	1
Fire	Burns / death	Ensure that all flammable waste is appropriately disposed of. Fire alarm. Fire procedure and fire stewards in area.	2	4
Electricity (Electric hand tools)	Burns, fire, electrocution	Regular PAT testing sticker on device. Visual inspection for exposed cords before use. Correct storage of portable electric devices.	2	4
Hand tools	Sharp edges on cut material	Wear gloves.	5	1

Likelihood		Severity	
1	Very unlikely to happen	1	Minor injury
2	Unlikely to happen	2	Major injury
3	Possible to happen	3	Loss of limb
4	Likely to happen	4	Death of an individual
5	Very likely to happen	5	Multiple deaths

Task 2b) Manufacture of the prototype

Candidate evidence

I have decided to make the prototype out of wood as it has similar properties to aluminium (even though aluminium is stronger). Tensile strength = 27.6 - 34.5 MPa of plywood (base and top) Pine lift arms Tensile strength = 104 MPa

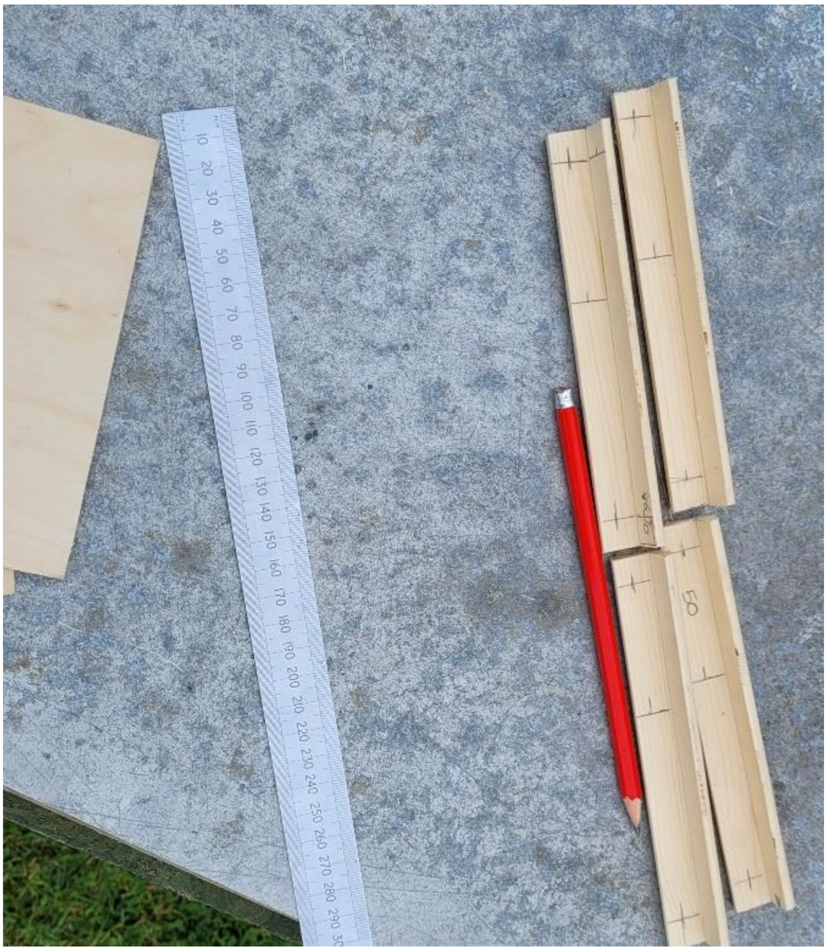
By building the prototype from wood, it means that if I notice something that I had not considered so far, I can make small modifications without cost expense.

To be timely, making the prototype **only** out of wood will be quicker and I will be able to meet my tight deadline. Welding will be substituted by using glue. Nuts and bolts will be used for the hinges and screws as fixings.

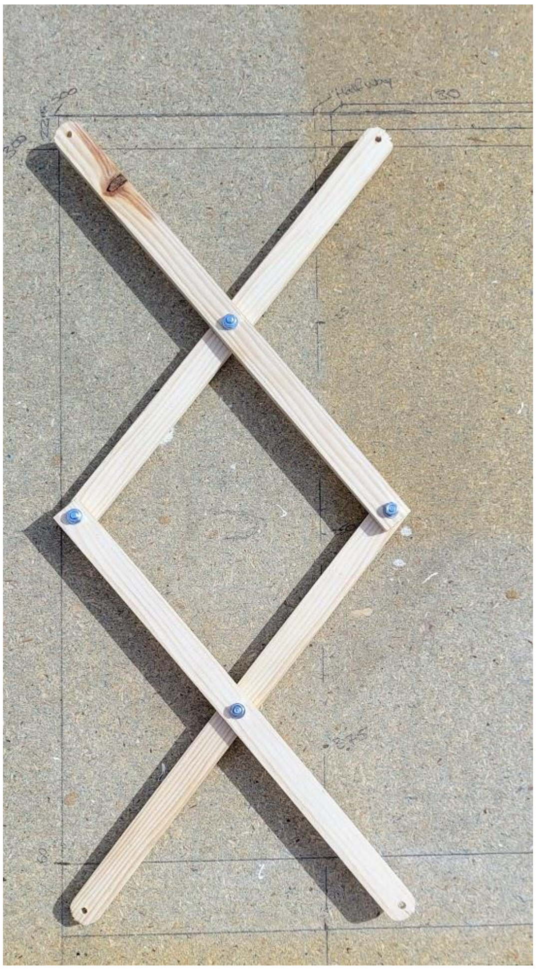
Wood is 100% recyclable as long as the metal has been removed, and the metal components can be reused by my college.

This is all built to a 1:2 ratio to give me a realistic perspective of the lift.

Photograph 1 shows the candidate's tool selection. These are all thoughtfully laid out, for example the nuts and bolts are kept in compartments and the wood parts are neatly collected in piles.

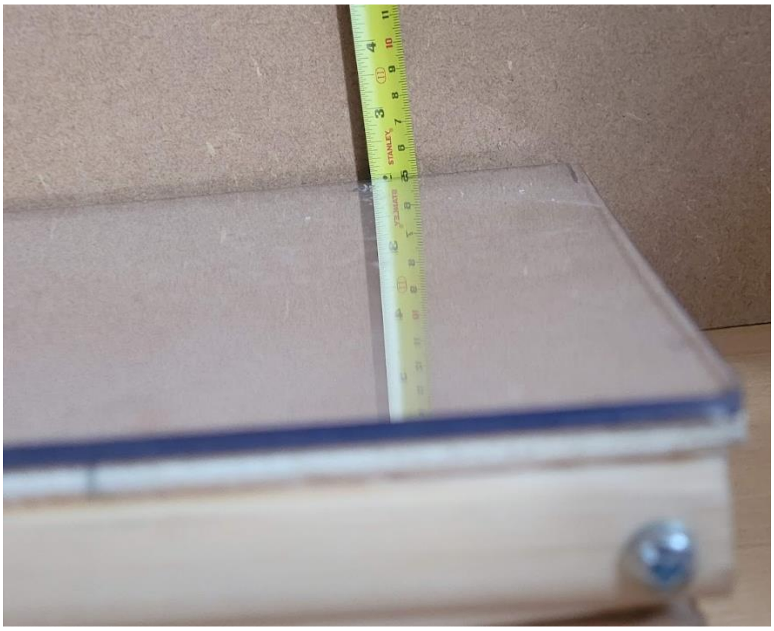


Photographs 2 and 3 show the sides for the runner rails marked up. The position of the holes for the runners is clearly marked and detailed annotations are included. The candidate has temporarily placed the mechanism sliders in situ for consideration.



Photographs 4 and 5 show the markings and the assembly process of the prototype using a rod board for accuracy. The holes have now been cut out of the rails and they are neat and well aligned.

Photograph 6 shows accurate cutting length and measuring to 300 mm, with an extra 10 mm to allow for the prototype to have some fore and aft movement on the runner.



Photograph 7 shows the lifting platform at its lowest height of 50 mm, which meets the scaled dimensions required. The low-friction surface on the top plate is also visible.

Photographs 8 shows the platform lift at the halfway point. The lift is functional and can be raised and lowered smoothly as planned using the threaded bar mechanism.

The cut legs of the scissor lift are rounded off and are smoothed out to prevent injury.

Photographs 9 and 10 show the platform lift fully extended to the maximum height. In the photograph, the platform is raised to slightly above 500 mm, but it was then lowered to 500 mm, as per the height requirement, using the threaded bar mechanism. The runner rails are neatly cut and are fully functional.

Practical observation form – Prototype

Assessment ID	Qualification number
8714-321	8714-31
Candidate name	**Candidate number**
Candidate A	CG12345
Centre name	**Assessment theme**
City & Guilds	Health and Safety Manufacturing

Complete the table below referring to the relevant marking grid, found in the assessment pack. **Do not** allocate marks at this stage.

Task	Notes – ***detailed, accurate and differentiating notes which identify areas of strength and weakness are necessary to distinguish between different qualities of performance and to facilitate accurate allocation of marks once all evidence has been submitted.***
Manufacture and assembly of lifting mechanism	The candidate correctly marked out the base and lifting platform using a scribe, pencil, engineer's square and steel rule. These were then accurately cut to dimension using a hacksaw and junior hacksaw, with all parts completed well within the specified tolerances in the design criteria and specification; whilst the parts were within tolerance, there was a very small variation in the linear dimensions due to operator misalignment. The edges were smoothed manually using files, producing a high level of surface finish. The runner rails and bar for the handle were cut on a hacksaw with excellent technique. The candidate then manually drilled holes in the correct locations using the pillar drill. They constructed with a simple positioning jig (also made by the candidate) to ensure the holes were produced within tolerance and repeatable. The runner rails were attached using glue, using a simple prefabricated jig. The bolts were fixed in place manually and correctly tightened. Care was taken not to overtighten. All work was completed safely and in line with their risk assessment and mitigating against all risks as they arose. The candidate implemented all the control measures in their risk assessment when using all of the manufacturing processes. They selected appropriate tools and ensured these were safe for use before beginning work. The prototype was fully functional when operated, with a smooth lifting and lowering motion, and meets all of the requirements of the design brief and criteria, and all but one of the requirements of the design specification.

Assessor signature	Date
Assessor 1	03/04/2022

Task 2c) Testing

Candidate evidence

All testing was completed on a wood substitute material with a ratio of 1:2. All records have been converted to demonstrate the ability to meet the requirements in full dimensions, as per the table below:

Component	**Original size (mm)**	**Build size 1:2 (mm)**
Top and base x2	600 × 600 × 5	300 × 300 × 2.5
Leg brace x2	600 × 2.5 diameter	300 × 1.25
Slider bracket x4	25 × 25 × 600	12.5 × 12.5 × 300
Legs x8	600x × 5 × 5	300 × 12.5 × 2.5
Slider support x2	600 × 25 × 25	300 × 12.5 × 12.5
Sliders x2	M5 × 1000	M2.5 × 500

	Design criteria	**How this was tested**	**Test outcome**
1.	The minimum size of the lifting platform must be at least 500 × 500 mm. Planned for 600 × 600	Measured with a meter rule.	600 × 600 mm pass
2.	The device must be capable of lifting 147 N (15 kg)	Functional test with 15 kg box.	Pass.
3.	The maximum effort required to raise the load should be 107 N	Applying a load of 10 kg (= 98 N) to the handle to see that this moved it.	Pass.
4.	The device should give a mechanical advantage of at least 2.2 to lift the maximum load	Design calculation.	MA > 100. Pass.
5.	The device must be capable of lifting the load from 100 mm above ground level to a height of 1 m to allow the boxes to be loaded/unloaded.	Functional test with 15 kg box.	Alignment +/- 1 mm. Pass.
6.	The device must be able to return to its start position	Functional test with 15 kg box.	Pass.
7.	The mechanism should be operated by a lever	Functional test.	Pass.
8.	The lever must be positioned at a height between 0.1 and 1.5 m	Measured with a meter rule.	Between 0.1 and 1.5 m depending upon platform height. Pass.

9.	The device must weigh less than 15 kg	Measured on stores scales.	14 kg. Pass.
10.	The lifting platform should be manufactured from aluminium (wood used as a substitute).	Checked materials certificate.	Pass.
11.	The lifting platform should have a surface with low friction	Checked materials certificate was nylon and functional test.	Box slid on without difficulty Pass.
12.	The platform must have no sharp edges	Silk test.	No snags. Pass.
13.	Any parts that move or rotate must be guarded or covered	Visual inspection during functional test.	Pass (when linen cover in place).
14.	At least 70% by weight of the materials used in the device should be recycled or recyclable	Based on measured weights of metal and nylon.	= 21.95/22 = 99.7% Pass.
15.	The device should be made from standard-sized forms of material	Standard sizes used – checked design drawings.	Pass.

Practical observation form – Testing of the prototype

Assessment ID	Qualification number
8714-321	8714-31
Candidate name	**Candidate number**
Candidate A	CG12345
Centre name	**Assessment theme**
City & Guilds	Health and Safety Manufacturing

Complete the table below referring to the relevant marking grid, found in the assessment pack. **Do not** allocate marks at this stage.

Task	Notes – ***detailed, accurate and differentiating notes which identify areas of strength and weakness are necessary to distinguish between different qualities of performance and to facilitate accurate allocation of marks once all evidence has been submitted.***
Testing of the prototype	The candidate scaled down the lifting device to make testing feasible, and all records were converted to what would be real if this was made from metal as proposed. The candidate tested starting and finishing height by winding up and down the lifting mechanism on the table with an appropriately mounted measuring tape. The candidate was provided with a box of the maximum dimensions and weight and performed an appropriate functional test. The candidate set up the device adjacent to the pre-positioned shelves provided by the centre to check starting and finishing height, however these were scaled down to match the scaling of the prototype. This was in a different location to the height testing but due to being made of wood the effort to relocate was minimal. The lifting platform was in line with the entry shelf when positioned by the candidate. The candidate easily pushed the box into position. The candidate turned the handle to raise the box until it was aligned with the exit packing table, then pushed the box onto the table. Approximately 30 turns of the handle were required, which appeared to be relatively low effort. The accuracy of alignment was determined by the number of turns from the user and appeared to be relatively good. No modifications were required for the mechanism to achieve the functional requirements. The candidate worked independently to lift the device from the test area.

Assessor signature	Date
Assessor 1	03/04/2022

Task 3 – Peer review

(Assessment themes: Reports)

For task 3, candidates need to produce the following pieces of evidence:

- candidate notes on the candidate feedback record form

  The candidate notes are not included in this document as the notes will vary from candidate to candidate and are not used to inform any other task.

- peer review feedback form.

  This is supporting evidence for assessors to see what feedback the candidate received and how they used it in their review for task 4, and will not be marked.

Task 3 - Candidate evidence

Peer review feedback form

Candidate evidence

Candidate name	**Candidate number**
Candidate B	CG01234
Centre name	**Centre number**
City & Guilds	12345

Question	**Feedback**
How well does the design meet the requirements in the brief?	*I think the design is generally good. It meets the requirements of the brief well. It can raise the box at the required height and support the weight. The runner rails are a good idea, as these would stop the lifting platform moving out of horizontal alignment when placed in the appropriate corresponding location. It lines up well with the picking shelf at the ground and the packing table at the higher level. I thought the quality of finish was very good and the product looked aesthetically pleasing.*
How appropriate is the equipment proposed for the design?	*The equipment used seems to be generally appropriate. It is light enough for the user to move around and seems to be robust, so I think it wouldn't get damaged by minor knocks as things are moved around in the stores area. I don't like that the height of the handle moves up and down with the lift, as that means the user has to bend over to use it, especially when it is close to the floor. Older workers might get a bad back from bending over a lot. Also, a wheel might be easier for a worker to turn than a handle.*
What are the implications to the business of the proposed design?	*It should make lifting things in the stores a lot easier. It will take longer to lift using the device than just lifting by hand, but because it is easier, this probably means that workers can lift more over the course of a shift. There would also be less risk of getting a bad back due to manual lifting, so workers are less likely to need time off for injuries. It should also mean less effort is needed for manual lifting, which would make workers get less tired and stressed.* *It takes a while to raise and lift each box, so it might mean that less work gets done in the stores and therefore affect the efficiency of the overall operation. If this could be improved in some way, then I think that would be a good thing.*
How can the design be optimised/ improved?	*I think you should include a larger threaded bar with a coarser thread leading to fewer turns of the handle. This would make it easier for the operator to use. I think that it could also be improved by adding a lip around three sides of the lifting platform so that when the user pushes the box on, it won't go too far.*

Task 4 – Evaluation and implementation

(Assessment themes: Health and safety, Design and planning, Reports)

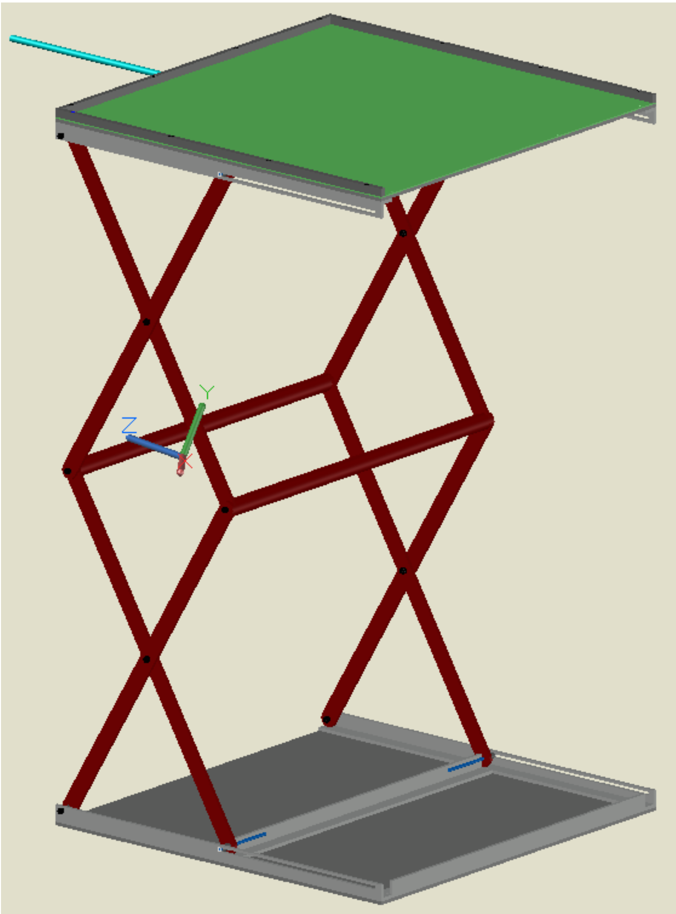
For task 4, candidates need to produce the following pieces of evidence:

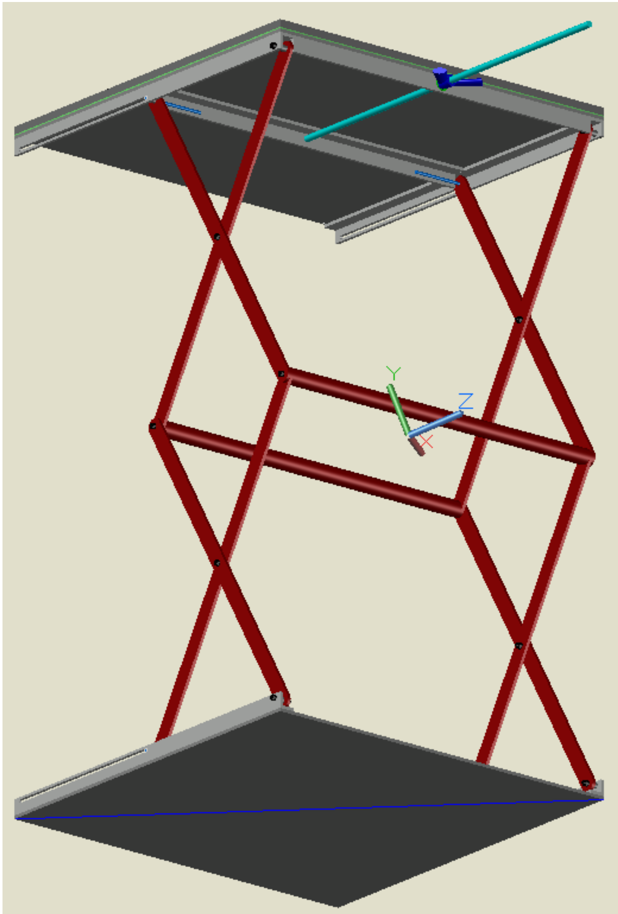
a) outcomes of virtual modelling
b) revision control document
c) evaluation and implementation report.

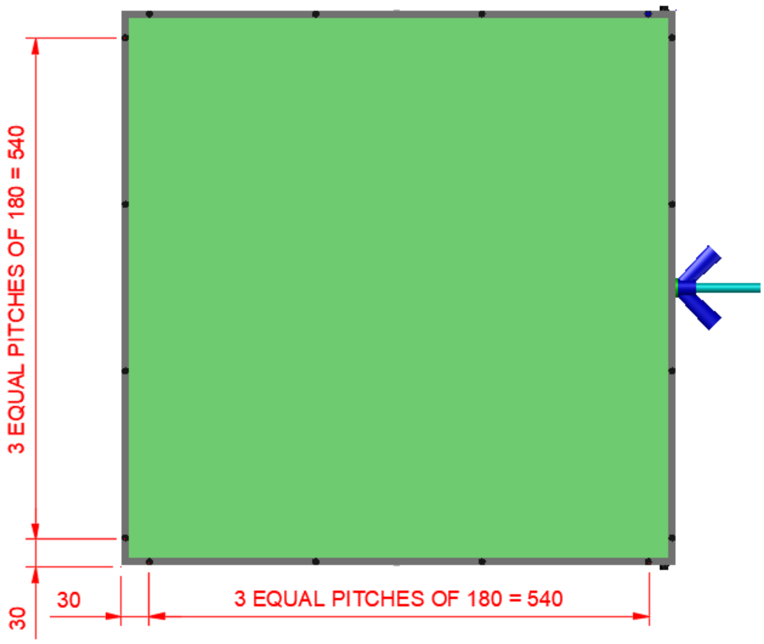
Task 4 - Candidate evidence

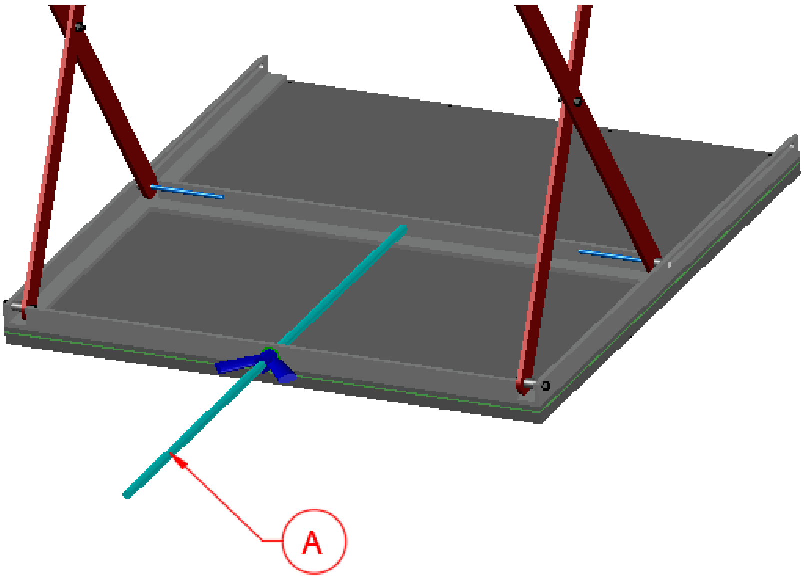
Task 4a) Outcomes of virtual modelling

Candidate evidence

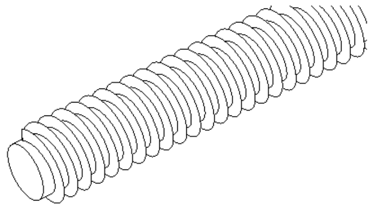








FRONT UNDERSIDE VIEW OF TOP PLATE



DETAIL A:
STUDDED BAR DETAIL
M10 COARSE THREAD

Task 4b) Revision control document

Candidate evidence

System type	**Manually powered mechanical lifting device**
System TAG number	A1B2C3
Department responsible for equipment	Design and Development department
System designed by:	Candidate A

Design description:
This is a device to lift boxes from at a height of 100 mm to 1 m. Boxes are removed from a picking shelf, are manually pushed onto the lifting platform, raised by turning a lever, and then pushed onto a packing table in the opposite direction. The boxes are cuboid with a maximum side of 500 mm and a maximum weight of 15 kg. The device uses a scissor-type lift which is located to the sides so that it does not impede movement and connected to the base and a raising platform. Runner rails help to ensure that it remains in the correct alignment and provide a leverage point. The user raises and lowers the platform to the height and position needed. The mechanical advantage provided by the mechanism means much less effort is needed to lift the boxes compared to lifting by hand.
Changes to existing system:
Candidate B made a number of suggestions which I have considered. They suggested changing the lever to a wheel as they thought this would be easier to turn. I went back to check the ergonomics and anthropometric data tables that I used when completing the specification, and from this I saw that this would not actually result in an improved outcome, so this change was rejected. Another suggestion was a larger threaded bar with a coarser thread (M10) leading to fewer turns of the handle. I agreed with this change as it has the advantages of reducing the number of turns, which means that it is more convenient and user friendly for the operator. Finally, Candidate B suggested adding a lip around three of the sides of the platform. to ensure that the boxes could not be pushed too far. Again, I agree with this change as it would improve the functionality of my design and make it more commercially viable. This could be made from a thin strip of nylon or acrylic and attached with machine screws, countersunk to avoid the risk of snags against the operator's hands or clothing.
Changes to existing technical documentation:
An additional engineering drawing would be required for the lip so that it could be cut to the correct size. The engineering drawings for the lifting platform and nylon sheet would need to be modified to include tapped holes so that the lip can be attached. Also, to accommodate a larger threaded bar the dimensions of the top mechanism housing will change to accommodate this. The handle will require adjustment due to a thicker bar being used. The standard operating procedure (SOP) for making the lip would need to be created, and the SOPs for the production of the lifting platform and nylon sheet would need to be modified to include the tapped holes, to provide instructions for the safe manufacture of these parts.

The bill of materials needs to be amended to add the lip and four M4 × 8 machine screws to attach the lip. The design criteria and specification and any technical manuals explaining the use of the system would still be valid without amendments.
Comments:
Overall, I am happy with the feedback received and have acted on the main points given by each candidate as they improve the design. I have suggested changes based on these that would help my design to meet the criteria more effectively.

Validation performed by:	Assessor 1

Prototype approved by:	Assessor 1

Date:	16/06/2022

Task 4c) Evaluation and implementation report

Candidate evidence

Evaluation –

Before manufacturing the prototype, the mechanical advantage was calculated to ensure it met the specification requirements. Using relative data for a handle of 200 mm, the mechanical advantage was calculated to show the efficiency of the lifting activity:

Mechanical advantage = (load × pitch / typical efficiency) / (2π × handle length) / applied force = 441 / ((147× 1.5)/1.16) / (2π × 200) = 15.1

A virtual model was used to ensure that the parts fitted together correctly and to simulate the loading, to give confidence that the structure would be sufficient to resist the stresses caused by the maximum loading.

The evaluation of the physical prototype was carried out by comparison with the specification.

Functional testing was used to assess several criteria, as this gives the best indication of how well it will work when it is used in context. This involved setting up the lifting device in the scenario described in the brief, with a picking shelf and a packing table at the correct height and moving a box of the maximum possible size and weight. The lifting platform was manually aligned and moved from the picking shelf onto the platform and from the platform onto the packing table, achieving accurate alignment in both the pick-up and drop-off positions. This required minimal effort to raise and lower the platform (due to the mechanical advantage) and push the box on and off the surface (due to the lubricity of the nylon sheet).

The functional testing was supplemented by objective tests including:

- measuring the main dimensions of the platform with a meter rule to ensure it could accommodate the maximum stated dimensions
- checking the weight of the mechanism was under 15 kg using scales, so that it could be lifted by a worker acting alone
- carrying out a silk test to ensure that there were no sharp edges
- using the materials certificates to calculate the proportion of material that could be recycled.

Additionally, the drawings were inspected visually to verify that all the components would be manufactured from standard forms and sizes of material, to minimise costs.

Overall, the testing showed that all of the requirements of the design specification were achieved.

While the prototype worked well and met the requirements of the specification, it can be further improved to satisfy the brief even better:

- Include a heavy linen cover for the front of the scissor lift mechanism. This acts as a guard to stop other things getting caught when the lift is raised and lowered (which would otherwise be a risk during use).
- Put a nylon 'lip' around the edge of the lifting platform, so boxes cannot be accidentally pushed off the platform, reducing the risk of damaging the boxes or injuring workers.
- Add wheels to the base so that it is even easier for the user to move it.

Implementation –

For a third party to implement the prototype they will need the following information and documentation:

- The initial design criteria from the brief and final design specification from task 1.
- The bill of material from task 1, so suitable materials can be purchased.
- The engineering drawings for each of the individual components from task 1, to provide dimensional requirements for manufacturing activities.
- The general assembly drawing from task 1, to show the relative locations of the parts during assembly.
- The risk assessments from task 2 and standard operating procedures (SOPs) or a production plan for making and assembling the parts, to facilitate the safe and reproducible manufacture of the mechanism.

A copy of the virtual model may also assist so they can see what the assembled device looks like.

The main health and safety considerations for the manufacturing Include:

- all workers should be trained and competent using the machines
- machine guards should be used where applicable
- personal protective equipment (PPE) such as safety glasses and gloves (for handling the cut parts, except when using the lathe, where gloves would increase the risk of injury)
- overalls should be worn to protect clothing
- loose clothing and hair should be tied back
- the standard operating procedures (SOPs) should be followed during production activities
- all the machines should be well maintained.

Guidance on the exemplar marking

Marking Grids for each assessment theme are found within the Assignment Assessor Pack and gives guidance on banding descriptors, marks available within each band as well as indicative content that provides guidance on knowledge, understanding and skills within the assessment theme.

For the purposes of these materials the Marking Grids used can be found in the Sample Assessment Materials here.

Within this standardisation pack, a partially completed CRF form has been provided that outlines how an assessor has awarded marks against the candidate evidence for a number of the assessment themes using the Marking Grid included in the Sample Assessment Materials.

For exemplification purposes, an explanation of how the marker has determined the mark to be awarded is provided, this exemplary document showing

- How the marker has first considered the marking bands available and determined within which band the evidence best fits
- Subsequently, consideration within the determined band and justification for the mark to be awarded within that band.

Candidate Record Form (CRF) – Mechanical D&D (8714-321)

Health and safety												
	Band 1				Band 2				Band 3			
	1	2	3	4	5	6	7	8	9	10	11	12
Mark 10	The evidence produced for each task, such as the design specification, risk assessment, manufacture of the prototype, assessors' observations, testing, and evaluation clearly evidences the prototype was produced in a safe manner. The risk assessment is detailed and clearly identifies most of the associated risk factors, risk control measures and most potential risks and hazards. Assessor observations provide some generic responses in comparison to candidates detailed evaluation of Health and safety followed during preparation and throughout tasks with all work completed safely. There are a comprehensive range of health and safety considerations as part of the design, evaluation, and implementation. Most risks and hazards are mitigated as they arise, yet do not go into detail for all risks associated with all tools and equipment not suggesting for example what hand tools will be used and associated risks. Similarly portable electric tools that will be used to manufacture the device. Overall, the evidence provided meets band 3 – 10 marks.											

Design and planning												
Drawings and diagrams												
	Band 1				Band 2				Band 3			
	1	2	3	4	5	6	7	8	9	10	11	12
Mark 10	Drawings and diagrams are clear and concise containing most of the appropriate information needed for a third party to reproduce them. Sketches are developed in comprehensive detail demonstrating excellent knowledge and understanding through proposed solutions with various ideas for handles, safety features and incorporation of pulleys. Annotations and dimensions suggest how proposals fully meet the design specification. The engineering drawings produced are mostly compliant with some correct conventions, however the drawings incorporated are not orthographic drawings and lack all clear dimensions. Overall, the evidence provided meets band 3 – 10 marks.											

Manufacturing									
Prototype/model									
	Band 1			Band 2			Band 3		
	1	2	3	4	5	6	7	8	9
Mark 8	The prototype model is functional without modifications, such as pushing the box into position and being able to raise the platform until the box is aligned with the exit packing table. Approximately 30 turns of the handle are required with relatively low effort and appear to be relatively good in operation. The assessor observation report suggests all but one of the specification requirements were met with no further explanation, yet the candidate's evaluation								

	provided suggests three suitable modifications to improve the design – including the linen cover/guard for moving parts. Overall, the evidence provided meets band 3 – 8 marks.

Developing						
	Band 1		**Band 2**		**Band 3**	
	1	**2**	**3**	**4**	**5**	**6**
Mark 6	An appropriate selection of tools, equipment and processes is appropriate to the task resulting in a finish that is of high-quality. This is evident with the inclusion of a drilling jig to ensure accurate positioning of drilling holes, along with a jig to assist with gluing. The prototype is fully functional when operated. Overall, the evidence provided meets band 3 – 6 marks.					

Reports						
Records						
	Band 1		**Band 2**		**Band 3**	
	1	**2**	**3**	**4**	**5**	**6**
Mark 5	Reports are detailed and accurate with correct technical industry terminology throughout. Test records are detailed with various tests including objective and functional testing conveying appropriate information. Test records portray all appropriate information and some inaccuracies in recording of test outputs and measurements. Such as applying a 10kg load to the handle. Overall, the evidence provided meets band 3 – 5 marks.					

Internal assessor signature	**Date**

Total
***/90**

* Please Note that the Total Mark (90) applies to the full assignment including all Assessment Themes

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About City & Guilds

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We work with governments, organisations and industry stakeholders to help shape future skills needs across industries. We are known for setting industry-wide standards for technical, behavioural and commercial skills to improve performance and productivity. We train teams, assure learning, assess cohorts and certify with digital credentials. Our solutions help to build skilled and compliant workforces.