

T Level Technical Qualification in Engineering, Manufacturing, Processing and Control (8730-13)

**8730-034 Employer-Set Project
Exemplar – A Grade
Summer 2025**

Contents

Introduction	2
Task 1 Research.....	5
Task 2 Report	16
Task 3 Design.....	26
Task 4 Present.....	38

Introduction

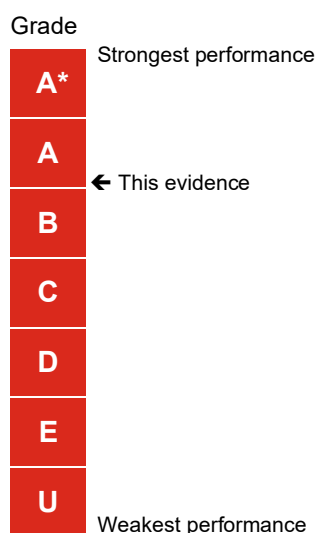
Summer 2025 Results

This document is aimed at providers and learners to help understand the standard that was required in the summer 2025 assessment series to achieve an A grade for the 8730-034 Engineering, Manufacturing, Processing and Control Employer-Set Project (ESP).

Providers and learners may wish to use it to benchmark the performance in formative assessment against this to help understand a potential grade that may be achieved if a learner was to attempt the next summative assessment series.

The Employer-Set Project is graded A* to E and Unclassified.

The exemplar evidence provided for the A grade displays the holistic standard required across the tasks to achieve the A grade boundary for the summer 2025 series.



The Employer-Set Project brief and tasks can be downloaded from [here](#).

Important things to note:

- We discussed the approach to standard setting/maintaining with Ofqual and the other awarding organisations before awarding this year. As in 2024, we have agreed to take account of the newness of T Level qualifications in how we award, to recognise that students and teachers are less familiar with the assessments in the first years of awards, whilst also recognising the standards required for these qualifications (<https://www.gov.uk/government/publications/ofqual-guide-for-schools-and-colleges-2025/ofqual-guide-for-schools-and-colleges-2025#grading>). Ofqual guide for schools and colleges 2025
- The exemplar evidence presented, as a whole, was sufficient to achieve the A grade. However, performance across the tasks may vary (i.e. some tasks completed to a higher/lower standard than an A grade).

Marking of this Employer-Set Project is by task and Assessment Objective, below is a summary of these along with the mark achieved by the evidence presented and the maximum mark available for each aspect.

Task	Assessment Objectives	Mark achieved	Max mark available
Task 1 Research	- AO1 Plan their approach to meeting the project brief - AO2a Apply core knowledge - AO3 Select relevant techniques and resources to meet the brief	4	9
	- AO2b Application of core skills	3	6
Task 2 Report	- AO1 Plan their approach to meeting the project brief - AO3 Select relevant techniques and resources to meet the brief	4	6
	- AO2a Apply core knowledge	3	6
	- AO2b Application of core skills	4	6
Task 3 Design	- AO1 Plan their approach to meeting the project brief - AO3 Select relevant techniques and resources to meet the brief	4	6
	- AO2a Apply core knowledge	3	6
	- AO2b Application of core skills	3	6
	- AO5a Realise a project outcome – was the right outcome achieved - AO5b Review how well the outcome meets the brief, how well the brief was met, the quality of the outcome in relation to the brief	4	6
Task 4 Present	- AO1 Plan their approach to meeting the project brief - AO3 Select relevant techniques and resources to meet the brief	5	6

	- AO2a Apply core knowledge	4	6
	- AO2b Application of core skills	5	6
	- AO5a Realise a project outcome – was the right outcome achieved - AO5b Review how well the outcome meets the brief, how well the brief was met, the quality of the outcome in relation to the brief	4	6
Maths	- AO4a Use of Maths skills	3	3
English	- AO4b Use of English skills	2	3
Digital skills	- AO4c Use of Digital skills	3	3

What evidence was being assessed for the Maths, English and Digital skills:

Maths:

- Research notes – maximum load supported by the gripper (Task 1)
- Report – any calculations relating to load supported by the gripper, his method of powering and the reason for selection (Task 2)
- Relevant design calculations related to annotated drawing - calculations of max load supported by gripper and forces required for the gripping mechanism (Task 3)

English:

- Research notes (Task 1)
- Report (Task 2)
- Reflective notes (Task 3)
- Video of presentation and materials to support presentation (e.g. slides etc) (Task 4)

Digital:

- Types of sources used for Research (Task 1)
- Report (Task 2)
- Drawings (Task 3)
- Presentation materials (slides, handouts, notes etc) (Task 4)

Task 1 Research

Assessment number (eg 1234-033)	8730-034
Assessment title	Employer-Set Project

Candidate name	<first name> <surname>
City & Guilds candidate No.	ABC1234

Provider name	<provider name>
City & Guilds provider No.	999999a

Task(s)	1
Evidence title / description	Evidence expected for marking: Research notes (typically 1500 words) List of references/sources Evidence submitted for marking: Research notes (typically 1500 words) List of references/sources
Date submitted by candidate	DD/MM/YY

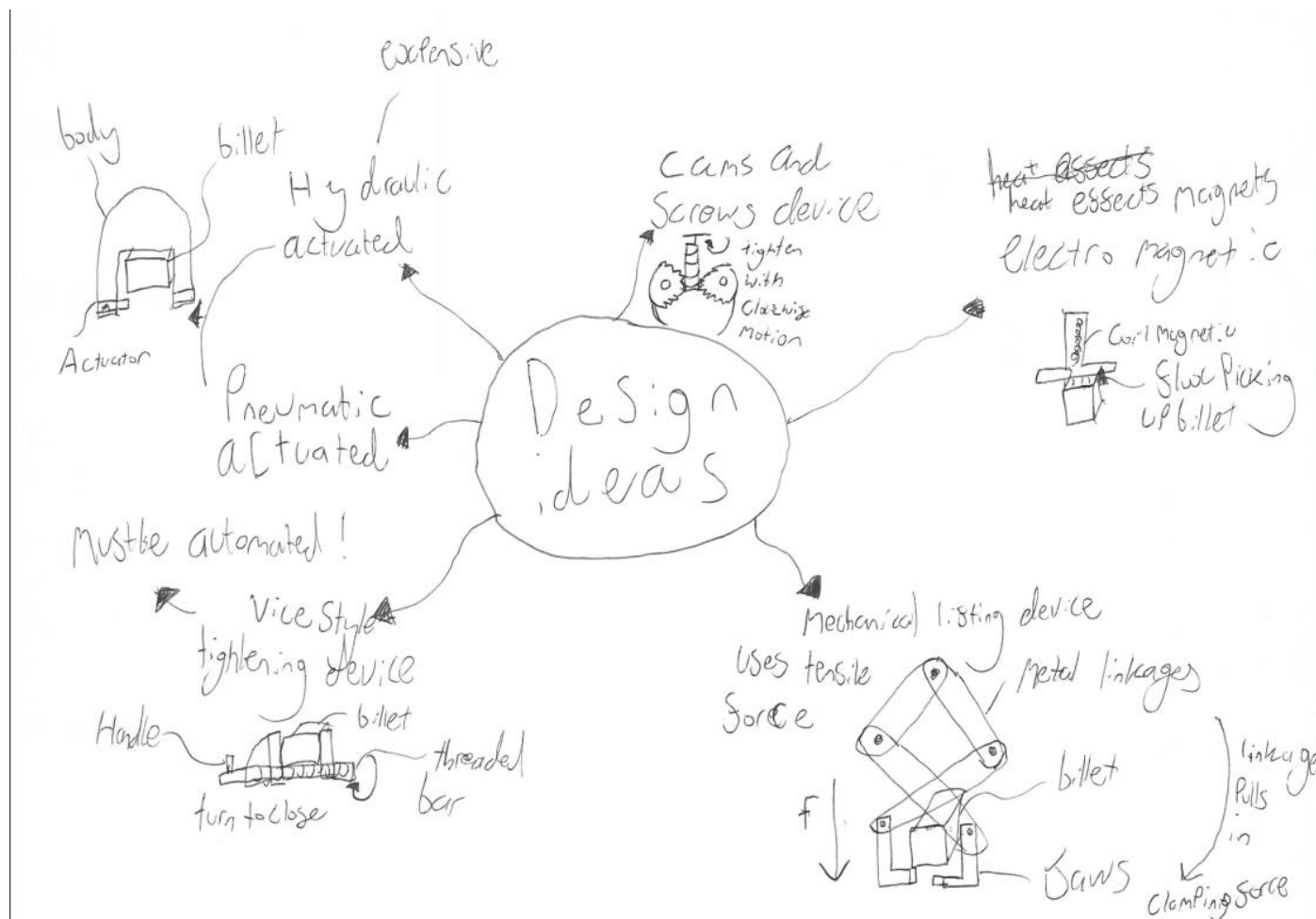
Task 1- Research

The Brief-

I Have been tasked by KSEW (Kent State Engineering World) a manufacturer of heat-treated aerospace components to design an automatic gripper mechanism. It must be able to attach to a robot arm and carry a rectangular section of billet with the dimensions of 50mm width x 40mm depth x 1000mm length which has a mass of 16kg. It must also be able to withstand a heat of 600 degrees Celsius for 15 seconds with one minute allowed for the device to cool and disperse the heat. The gripper will lift the billet at the centre. The device will attach to the robot with a base plate with the dimensions 170mm radius with 12 holes 10mm in diameter on a pitch circle diameter of 150mm.

Initially I will research possible designs of the mechanism.

Designs-



Insert of my hand drawn mind map.

I heavily considered using a device using a thread and cams as well as a vice style gripper, however the brief states that it must be automated so they will not be

suitable to use for the project. Therefore, I will be further researching actuated grippers and a mechanical gripper using the linkages.

Before that, it is not stated in the brief what variation of robot is being used or in which plane the billet will be carried (vertically or horizontally) so I must first consider this and research any possible variations and conclude on what to use for my gripper.

Cartesian Robots-

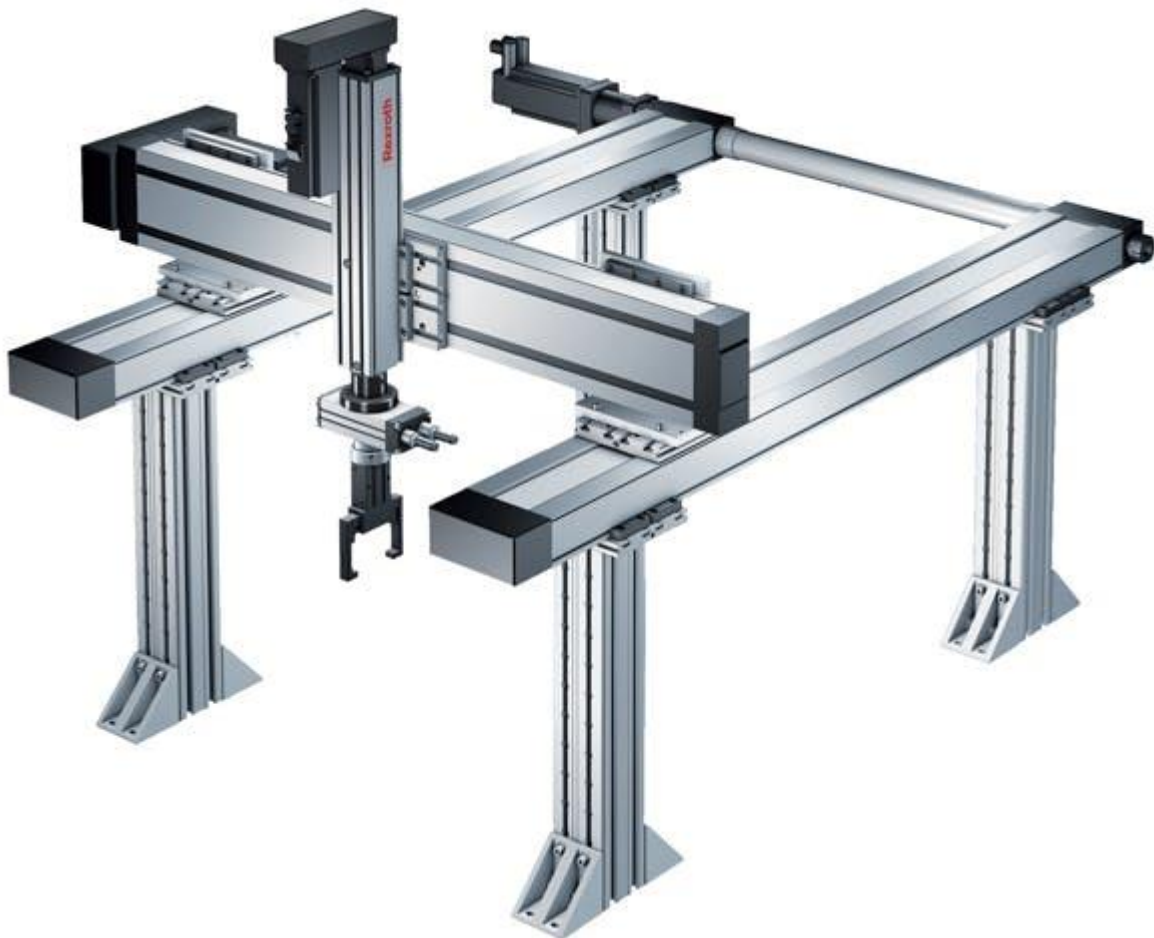


Diagram of a cartesian robot. **Machine Design. (2013).**

A Cartesian robot moves in straight lines at right angles to each other giving the 3 axis X, Y and Z. Some of these only move in 2 directions also, left and right, up and down. The arm can be mounted vertically like the one shown in the diagram or horizontally.



Applications for Six-Axis Robots

- Due to their full range of motion, six-axis robots can automate just about any application.
- The most common include:
 - Arc Welding
 - Spot Welding
 - Painting
 - Material Handling
 - Material Removal
 - Assembly

Six-axis robots are a type of articulated robot that can move in the x, y, and z planes. In addition, they can perform roll, pitch, and yaw movements. This makes the movements of these robots like a human arm, one reason they are ideal for taking over production lines. The defined movements for each axis of a six-axis robot include:

Axis One - Axis one is located at the base of the industrial robot. With this axis an industrial robot is able to move its arm from left to right for a complete 180 degrees of motion from its centre. This provides a robot with the ability to move an object along a straight line.

Axis Two - Axis two controls the robot lower arm and provides the ability for the movement of forward and backward extensions. This allows a robot to lift an object, move it sideways, up and down, or to set the object down along the x or y planes.

Axis Three - Axis three provides industrial robots with the ability to raise and lower the upper arm, expanding their vertical reach.

Axis Four - Axis four helps control the movements of the robot and change the orientation of an object through a rolling motion. The upper robotic arm will rotate in a circular motion in the roll movement.

Axis Five - Axis five is responsible for the pitch and yaw movements. Pitch movements involve moving the end-effector up and down. While yaw movements move the end-effector left and right.

Axis Six - Axis six is the wrist of an industrial robot. This axis is responsible for the complete 360-degree rotations of the wrist. **Robots Done Right. (2025).**

While a six-axis robot has the practicality advantage with much more range of tasks possible and a lot more freedom of movement, these are not required and a cartesian robot is much simpler in design. Ergo, it is much less likely to fail and will be considerably cheaper for the company.

Force Calculations-

When used vertically, the only significant force acting on the gripper will be the weight of the bar- The mass of the bar(16Kg) times the gravitational field strength on earth (9.81 N/Kg).

$9.81 \times 16 = 156.96\text{N}$ of force that the bar will experience. So, the gripper must be able to hold or clamp with at least 156.96N to hold the bar in place.

If the arm is mounted to the gripper horizontally this starts to cause a problem. There will be a bending moment on the robotic arm as the arm will act as a cantilever beam, fixed at one side with force acting on the other. If we assume the arm is a meter long and we only consider the weigh of the bar and not the gripper since it is yet to be designed, the arm will experience a bending moment of 159.96Nm since moment is force x distance ($156.96\text{N} \times 1\text{M}$)

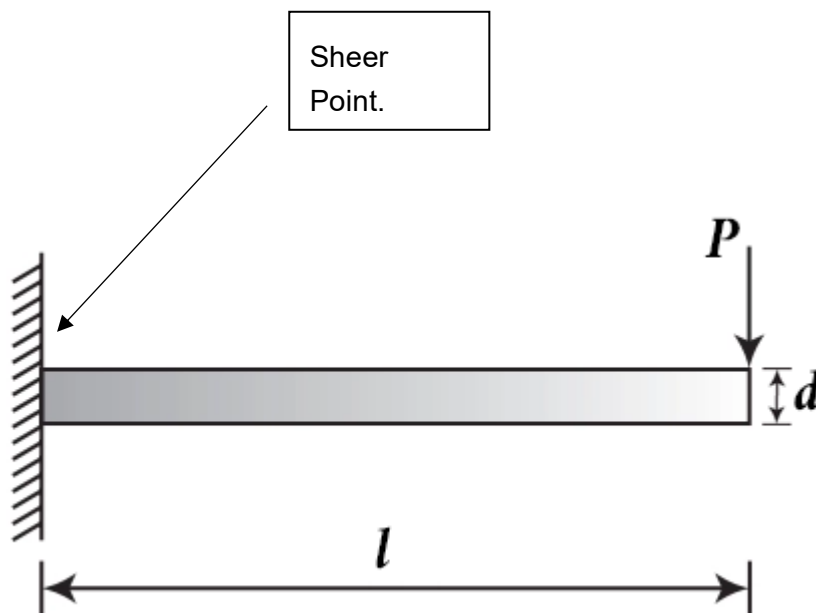


Diagram of a cantilever beam **Stack Exchange. (2022).**

When a cantilever beam experiences a force, it will cause the beam to bend at the centre if the load is excessive enough, it could also cause the beam shear from the join to the fixed point.

Types of grippers-

Actuated-

For a pneumatic or hydraulic actuated device, it must achieve the force of 156.96N

Example calculation of force applied by a small actuator-

$$F_1 = P \times A_1 = P \times (\pi/4) \times D^2 = 706.9 \text{ N}$$

Where pressure is a maximum of 10 bar(P) according to **ISO 15552**

The diameter of the piston head is 30mm(D) and piston area is 706.9mm squared (A)

British Pneumatics. (2025).

Therefore, an actuator is more than able to hold the weight of the bar. This is not considering friction on the piston and any force affecting systems caused by the design of the gripper (levers etc.) as I have not chosen a design yet.

Since a hydraulic actuator is usually more precise and powerful than a pneumatic one it is safe to assume that a hydraulic actuator that is similar in size to the pneumatic counterpart will be able to hold this force with relative ease.

However, the problem with both is that they require a system to run them which is an expensive upfront cost if the infrastructure isn't there already since this is a new idea from the company. An air compressor for this application would be around £500 which isn't a huge considering the budget of a large company, but a hydraulic system would be a lot more expensive and there are cheaper alternatives that do the job just as effectively.

Electromagnet-

An electromagnetic gripper would work very similarly to an electromagnet you would find at a car recycling plant where they are used to pick up heavy vehicles.

Electromagnets work by inducing a magnetic field by flowing a current through a wire usually made of copper as per Faraday's law of induction. They can also flow around a soft iron core which creates a very strong electromagnet.

The device would have a plate at the bottom which would be magnetised for the billet to be picked up and transported. This idea would be relatively cheap and easy to manufacture as a lot of standard electronic components could be bought in for assembly.

Contrarily, I think that having an electromagnet in a facility where producing component parts for aerospace could have repercussions. Firstly, any swarf from metal being cut or machine may be attracted to the machine so it would need regular cleaning. Also depending on the strength, it could cause any nearby light pieces of metal to be attracted which could be a health and safety risk depending on the effective area of the magnetic field.

There are also many health and safety considerations with having an electromagnet in the workplace like *A guide to the Control of Electromagnetic Fields at Work Regulations 2016* which provides information on:

- identifying sources of electromagnetic fields (EMFs) in your workplace.
- assessing the exposure of employees to EMFs.
- Action Levels (ALs) and Exposure Limit Values (ELVs)
- deciding what, if anything, you may need to do to protect your employees from the risk arising from exposure to EMFs.
- assessing and controlling any risks from EMFs in the workplace.
- protecting employees at particular risk

HSE. (2016).

Mechanical lifting device-

These grippers work by using the weight of the load they are carrying and the tensile force of the weight to pull the mechanism outwards towards the closed position like how a child's plastic claw toy would work.

Because they don't use any automated systems, they are much cheaper, but they still grip automatically as per the brief.

To handle the heat of the metal coming from the forge (600 degrees Celsius) I will need an insulating material at the tip of the grippers. This is very important as if too much heat is transferred to the robot, it could warp it or possibly break the internal components and cause a wide array of issues.



Photograph of a stone lifting clamp- Versa Block Clamp- **Aardwolf. (2011).**

The use of adjustable clamps is great for future proofing the design as different billets of metal may become high demand and need carrying as needs of customers and supplier demands constantly change in the industry.

Incorporating a future proofing into my design is a great way to save the company money in the long run not needing to change to different clamps for different applications.

This is an example of lean manufacture. I would not be able to use adjustable clamps as it must be an automated system, and I would not be able to use similar end caps as they look like a form of polymer and some polymers can not be used for the application.

Thermoplastics could not be used as they will melt, and PVC can absolutely not be used as it may release hydrogen chloride when cut or heated to high temperatures and this gas is an irritant to the lungs so it should be avoided. I can use this design as a start point and alter it to fit the specification of the brief like making it automated and making sure the materials, I will use are suitable.

Materials-

I will need to use a strong metal for the frames but one that is cost effective and machinable to be able to produce the piece.

Mild Steel –

Mild steel has a relatively high melting point of between 1450°C to 1520°C which is well above our 600 degrees Celsius. Steels with more carbon content than mild steel have a lower melting point. Mild steel has a carbon content of 0.16% and 0.29 % and it is suitable for forging, cutting, drilling, welding and is easy to fabricate. Mild Steel also has a high tensile strength of 440 N/mm² (Mega pascals) or 63,816.6 Psi (pounds per square inch) which makes it suitable for the application. With a safety factor of 4 the linkages and therefore the gripper will be able to withstand 110 MPa safely. 16kg will be able to be carried safely if the gripper is to be made from mild steel.

Stainless-Steel-

Strength

The most common type of stainless steel, 304, has a tensile yield strength around 210 MPa (30,000 psi) in the annealed condition. It can be strengthened by cold working to a strength of 1,050 MPa (153,000 psi) in the full-hard condition.

The strongest commonly available stainless steels are precipitation hardening alloys such as 17-4 and Custom 465. These can be heat treated to have tensile yield strengths up to 1,730 MPa (251,000 psi).

Melting point

The melting point of stainless-steel ranges from 1,325 to 1,530 °C (2,417 to 2,786 °F), depending on the alloy, which is near that of ordinary steel, and much higher than aluminium or copper.

Wikipedia. (2025).

Stainless is much more expensive than mild steel, has a lower tensile strength and is difficult to fabricate with, its only advantage is its corrosion resistance, but mild steel can easily be painted or heat treated to prevent corrosion for a fraction of the cost.

Therefore, I will use mild steel for the body.

Methods of manufacture-

Fabrication-

Using methods like cutting and welding to take raw material and make parts to assemble.

Forging-

Shaping pieces of metal by using heat and force to compress or flatten them into shape, this makes the product stronger but requires a high budget and equipment I will not have access to.

Casting-

Melting metal and pouring it into a die (mold) to cast a specific shape which reduces wastage. However, I do not have the necessary equipment, and this would majorly increase the price of the product unnecessarily.

Wasting-

Removing excess metal to cut out the desired shape often using a band or hacksaw.

Additive-

Building a piece layer by layer often using polymer in a 3d printer, this is often only used for models as polymer wouldn't be suitable for this project on account of its weak strength and poor heat resistance.

I must also consider how to cool the gripper.

Cooling-

I could use an air cooling or liquid cooling system, but I feel this would over complicate the design and add unnecessary pricing to the project. A ceramic pad would work to distribute the heat from the direct contact of the hot billet as ceramic is a fantastic insulator with a high melting point. Moreover, ceramic is good under compression which is good for the application as it will be compressed between jaws and the hot bar.

Maintenance Considerations-

The machine will have to be lubricated frequently for smooth operation. The high heat causes problems as I can't use a standard lubricant like WD-40 as it will just burn off. Therefore, a non-liquid, high temperature solution like 'Copperslip' or powdered graphite must be used instead.

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Task 2 Report

Assessment number (eg 1234-033)	8730-034
Assessment title	Employer-Set Project

Candidate name	<first name> <surname>
City & Guilds candidate No.	ABC1234

Provider name	<provider name>
City & Guilds provider No.	999999a

Task(s)	2
Evidence title / description	Evidence expected for marking: Written report (typically 2000 words) Evidence submitted for marking: Written report (typically 2000 words)
Date submitted by candidate	DD/MM/YY

Task 2- Report

I am basing my design on the assumption that we are using a cartesian robot in which the arm is arranged vertically and so will my device.

I will be manufacturing the body and base plate using mild steel. This is because it has desirable properties for the brief such as: a high melting point 1450 degrees C to 1520 degrees C, relatively high tensile strength of 440 MPa to support the weight of the billets 16kg. I will also be using standard parts like bolts and nuts to hold metal linkages together. I will be using m8 bolts to join the two base plates of the robot and gripper and m10 bolts to join the metal linkages. I will be using a ceramic plate on the jaws to disperse heat and insulate the rest of the robot to prevent heat transfer via conduction as much as possible. For the ceramic pads I will use zirconia as it is one of the cheapest, researched and readily available ceramic. It can be used safely up to 1000°C has low thermal conductivity, resistance to molten metals, wear resistance, high fracture toughness, high hardness **Precision Ceramics. (2025).**



A picture of a zirconia ceramic plate. **-HiTech Ceramics. (2017).**

To join the ceramic pads to the metal base I can fasten the plates with bolts. To ensure I do not fracture the plate I will use a tungsten carbide tipped drill bit which are often used for drilling ceramics. Also, zirconia is stronger than other traditional ceramics like tiles and is more resistant to fracture.

I will also paint the back and side of the jaws, the metal linkages and the front and sides of the base plate. This will help to prevent rusting and increase the lifespan of the product further reducing costing for the company in the long run. I am leaving the back side of the base plate and the front section of the

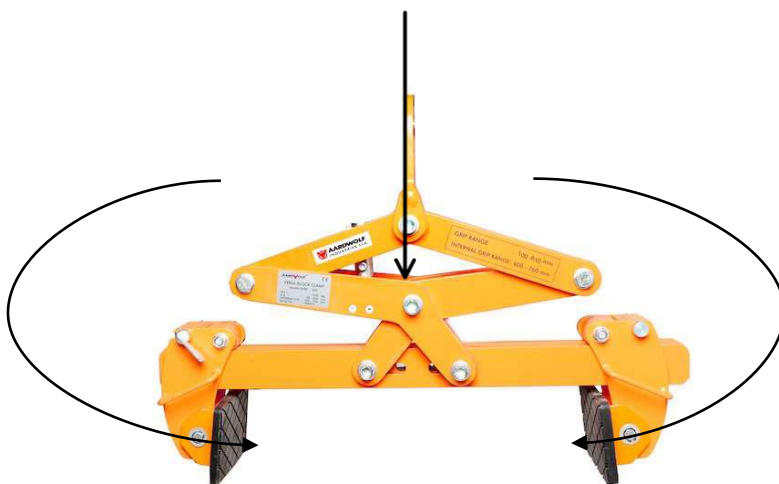
jaws unpainted as these areas are being fastened to other sections (the base plate to the robot and the jaws to the ceramic plates). These will have to be inspected for rust and well maintained. I must also make sure to use washers with the nuts and bolts to aid in the movement of the gripper. Making it move more freely with more ease.

Functioning Mechanism of the gripper-

I have opted for a mechanical based design not using any actuators or electrical devices like an electromagnet or a motor. The design works by using the weight of the metal and the clamps to act on the metal linkages which are arranged as such that they can pull downwards in inwards at the same time. This applies force to the sides of the bar which acts against gravity pulling it down to prevent it from dropping. In theory, the device will lower with the jaws opening to allow the hot bar to fit, it will then start to lift at which the jaws pull in and grip the bar. As the bar is lifted, the jaws tighten and fully hold the bar in place until it is transported, placed on the floor, and released. The clamp should work without needing any human assistance as per the brief.

Therefore, the gripper is not powered by any external energy source, it will use its own mass and the force of gravity, this is great from a cost saving perspective considering the rising cost of electricity and the large installation cost of a pneumatic or hydraulic system which I discussed in my research.

This is a simple diagram using a similar clamp to demonstrate how my design would function.



Photograph of a stone lifting clamp- Versa Block Clamp- **Aardwolf. (2011).**

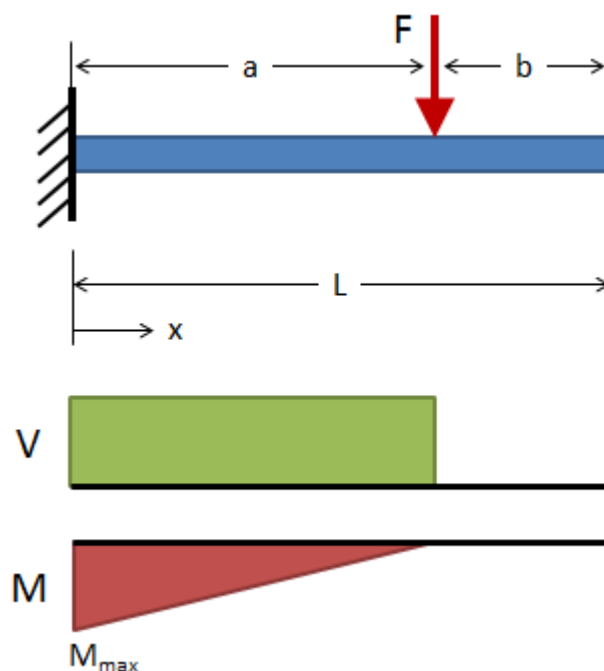
Like this clamp, my design will also be future proofed to save company money and to follow the 5 Rs of sustainability to protect the environment. Since my grips are not in fixed positions and can conduct a full range of motion, they can grip most standard size billets except for outliers like some cylindrical bars or plate.

Methods of Manufacture-

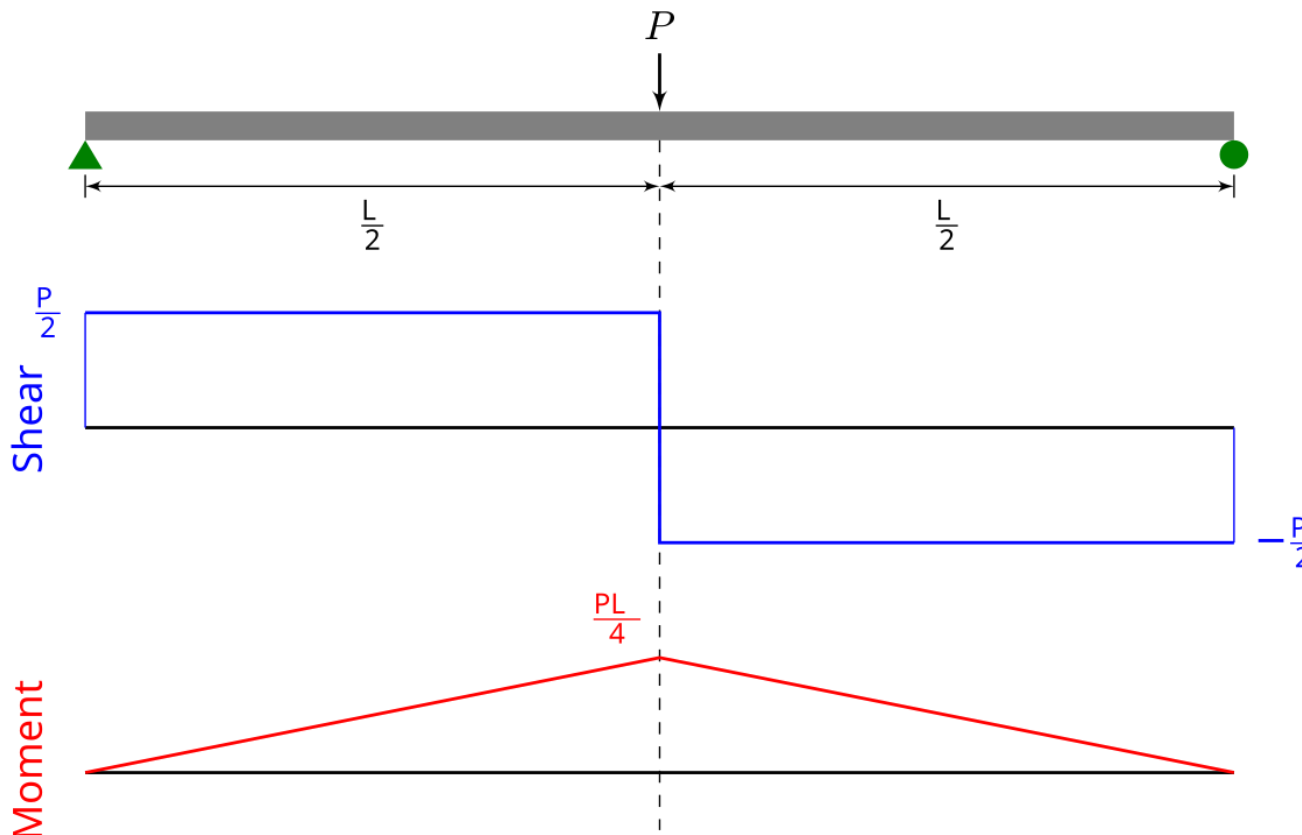
I will be using a combination of wasting, fabricating and some fitting and assembly to create this piece. For the base plate I will be able to cut the shape from 10mm plate and then drill the through holes using a pillar drill. I will use the same process for the linkages. To cut I could use a hacksaw or if it proves too difficult, I can use a grinder to cut it roughly to size and then file any excess or swap to a grinding disk. I will be able to order standard m8 and m10 nuts and bolts from supplier and I will also be able to order the zirconia plate to size and I can adjust it if it does not fit exactly as the manufacturer states since there can always be variation. I will be fitting the pieces together with nuts and bolts using an impact driver to tighten them together. I will need to weld a connector piece to the base plate for my device to be attached to the robotic arm which is a method of fabrication. I will need to finish and paint the component parts before assembly for ease of manufacture.

Forces acting on components-

Since I am using m10 bolts and m8 bolts I will have to be sure that they can withstand the forces they will be placed under. Any bolts will experience shear and bending force, but they will have to resist these to prevent being bent or sheered which would make the device unusable. Here, the bolt would be a cantilever beam with an intermediate load like this diagram.



Cantilever Beam- Intermediate Load- **MechaniCalc. (2014).**



Bending moment and shear force diagram. - **Wikipedia. (2024).**

Proof loads are normally given in Newtons in manufacturers tables but here we've converted them into kg force. The proof load is usually considered to be the absolute maximum load which a bolt should be asked to carry.

In practice, manufacturers will design their machinery so that the bolts carry a lot less than the proof load to give a good safety factor to the design.

Using the table below I can determine that if I use M8 and M10 bolts at the standard 8.8 grade they will be able to withstand 2,120kg and 3,370kg respectively. My design is relatively small, and light. I can expect it to weigh between 30-50 kg having used similar designs to my own to base my prediction on. From this, I can conclude that I will have no issue using bolts for this design.

Proof Loads for Standard Pitch Bolt

Size	Grade 8.8	Grade 9.8	Grade 10.9	Grade 12.9
M5	820 kg	923kg	1,180kg	1,380kg
M6	1,160kg	1,310kg	1,670kg	1,950kg
M8	2,120kg	2,380kg	3,040kg	3,550kg
M10	3,370kg	3,770kg	4,810kg	5,630kg
M12	4,890kg	5,480kg	7,000kg	8,180kg
M16	9,100kg	10,200kg	13,000kg	15,200kg
M20	14,700kg	N/A	20,300kg	23,800kg
M24	21,200kg	N/A	29,300kg	34,200kg
M30	33,700kg	N/A	46,600kg	54,400kg

Fine pitch bolts will be typically 10% stronger than coarse pitch bolts because less metal is cut away to make the thread. **Thomson Engineering Design. (2024).**

SOP- Safe Operating Procedure

- 1) Put on PPE for the workshop.
- 2) Conduct a Risk Assessment
- 3) Gather any materials and equipment.
- 4) Cut out the base plate from the mild steel.
- 5) Cut out the linkages.
- 6) Cut out the connector piece.

- 7) Cut out the pieces for the grippers.
- 8) Mark out the holes that will need to be drilled in all parts.
- 9) Drill all the through holes.
- 10) Inspect the ceramic plates and alter if needed.
- 11) Drill the holes into the ceramic plate.
- 12) Finish and paint the required pieces (sandpaper, file, polish if needed)
- 13) Put on PPE for welding.
- 14) Weld the connector piece.
- 15) Weld the grippers together.
- 16) Assemble the pieces working from top to bottom as it will be heavy when fully assembled.
- 17) Inspection of final product.

Gant Chart for Gripper Production								
Task	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Monday	Tuesday
Inspection								
Assembly								
Painting								
Finishing								
Welding								
Drilling								
Cutting								
Prep								
Design								
Research								
Planning								

Maintenance Requirements-

As previously stated in my research, regular lubricant will not work at the high temperature (600 degrees C) as it could just burn off. Therefore, a more specialist lubricant must be used. I suggested two alternatives, powdered graphite and 'Coppaslip' which is a brand name for a copper based powdered grease/ lubricant. The copper in the copper-based lubricant can sometimes be abrasive and cause wear so it would be more suitable to use the powdered graphite. Both can resist high temperatures above 600 degrees C so either will work for the application. I must consider ease of maintenance so that the device can easily be lubricated. While other similar devices use covers around their bolts that fit into the frame mine will not. I can also cut channels into the linkages to allow for lubricant to be applied directly to the joints where the bolts are since these cannot be sprayed like WD-40 or other commonplace lubricants.

Health and safety considerations.

I must comply with general HASAWA (Health And Safety At Work Act) 1974 and subordinate acts like PUWER 1998 (Provision and Use of Work Equipment Regulations), LOLER 1998 (Lifting Operations and Lifting Equipment Regulations) and ISO (International Organisation for Standardisation regulations for planning and design like ISO 900. I will need to conduct a risk assessment for the workshop before I begin working on the project.

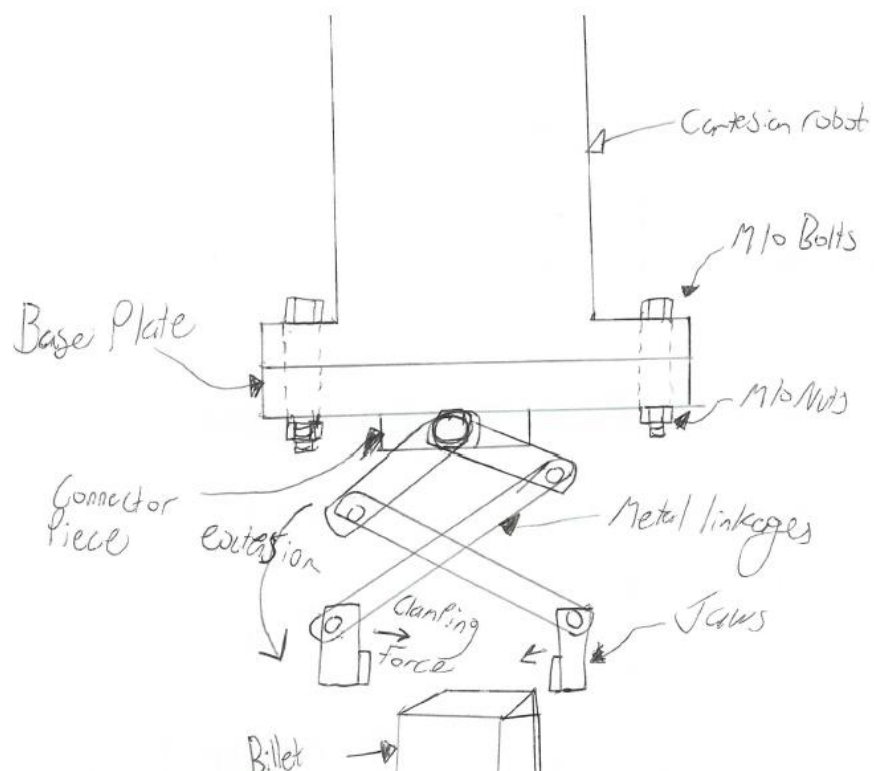
Risk Assessment for Gripper Production

Company name: isk assessment: 01/04/25

Activity/ Process/Operation	What hazards to health & safety exist?	Who might be harmed and how?	Likelihood (L)	Consequence (C)	Risk Level (L X C)	Control measures in place to reduce the hazard?	Risk level after control H/M/L	Additional control measure required?	Risk level achieved H/M/L
Cutting	Cuts on fingers Debris flying off Sparks (grinder)	User and Passerby	3	4	12	Gloves Isolated room	H	Correct Signage	M
Welding	Arc flash burns electrocution	User and Passerby	4	8 4	20 16	Gauntlets Welding mask Screening around welding area	M H	Separate welding bays Correct Signage	L
Drilling	Flying shrapnel/ getting caught in the chuck/dust deglazing	User and Passerby	3	5	15	Guards with stopping Auto System.	M	No loose clothing/jewelry	L
Painting	Inhaling Paint fumes getting paint in eyes	User and Passerby	3	3	9	Safety glasses dust mask	M	Using ventilation system	L

Link to video demonstration- https://youtu.be/nY_PYifExsY?feature=shared

Concept Design 1



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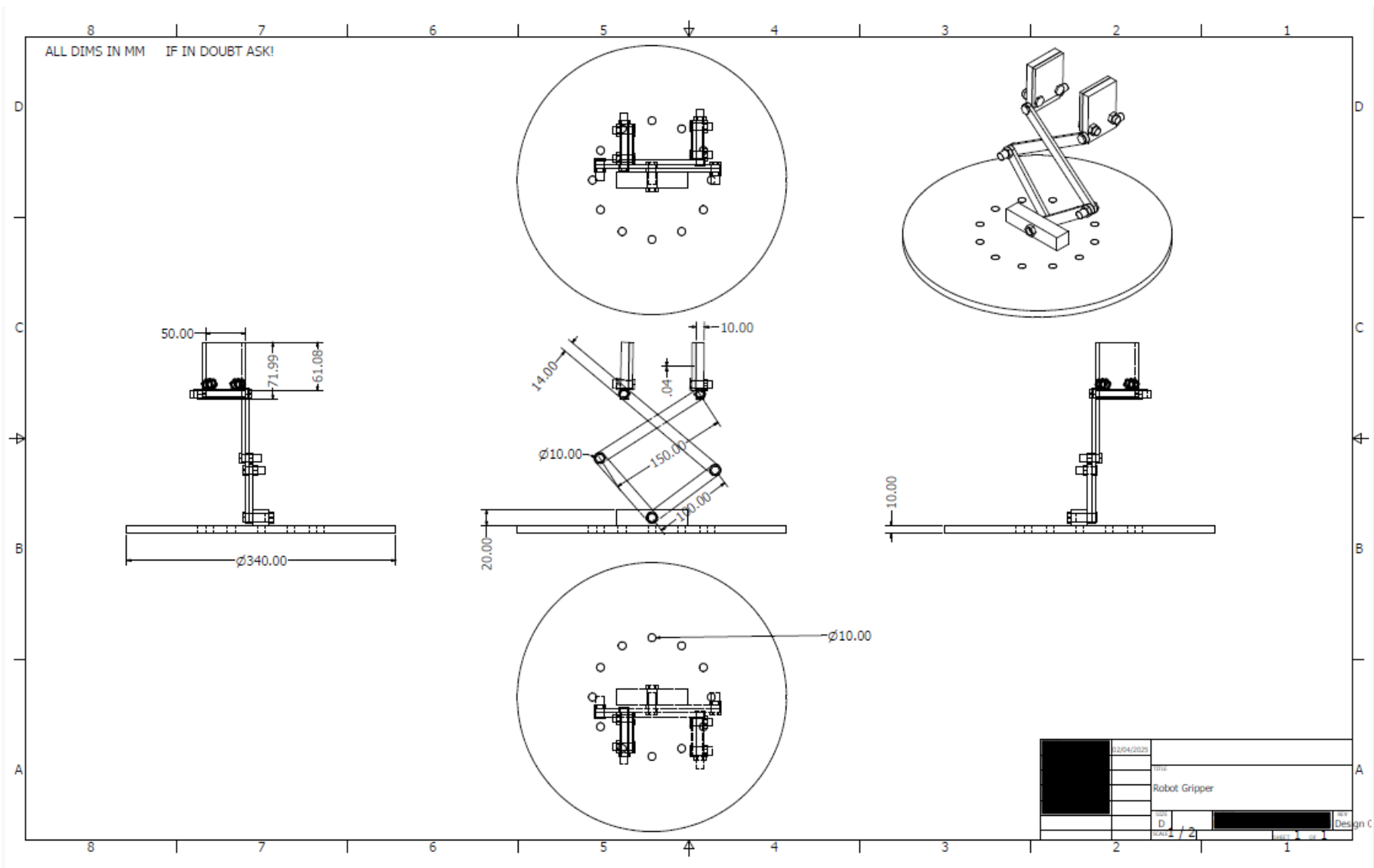
Task 3 Design

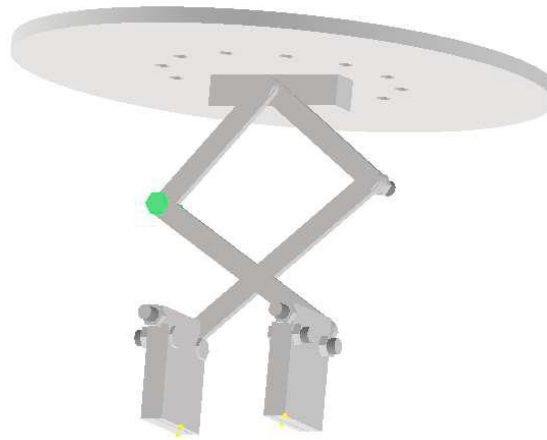
Assessment number (eg 1234-033)	8730-034
Assessment title	Employer-Set Project

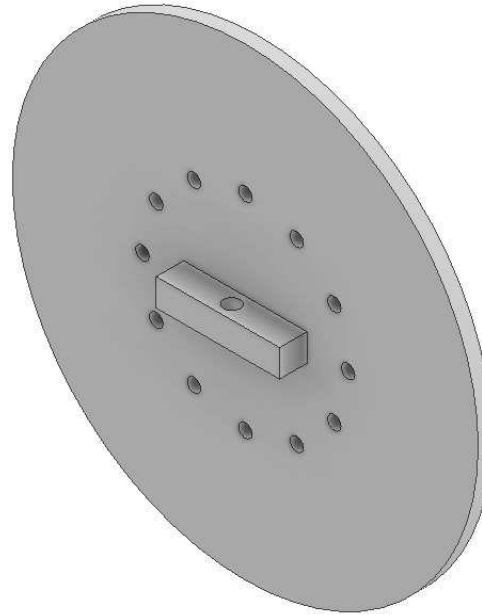
Candidate name	<first name> <surname>
City & Guilds candidate No.	ABC1234

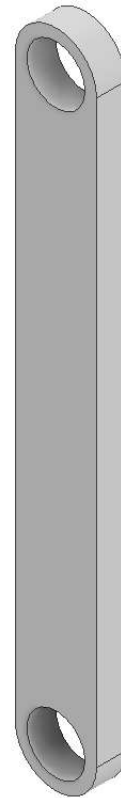
Provider name	<provider name>
City & Guilds provider No.	999999a

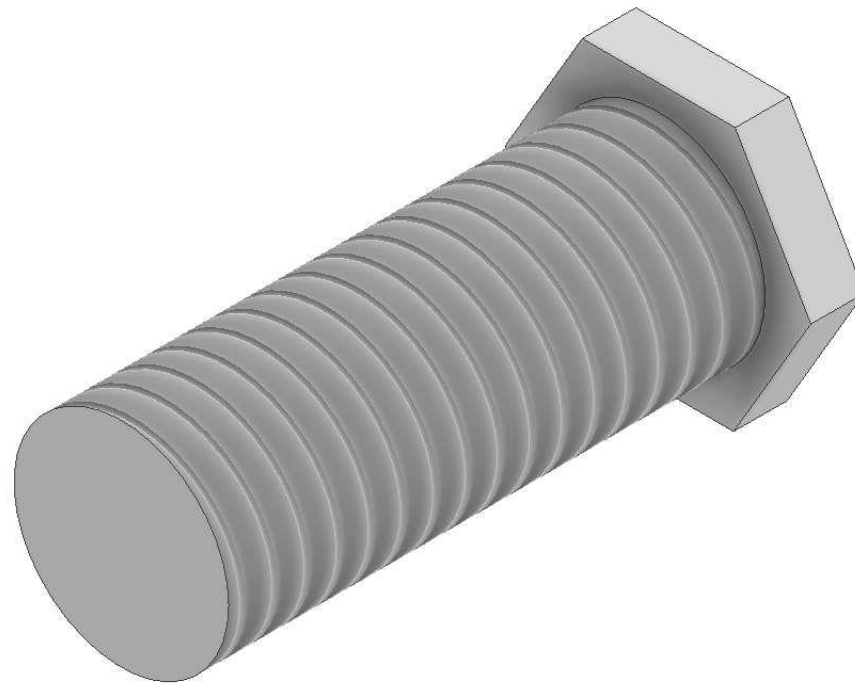
Task(s)	3
Evidence title / description	Evidence expected for marking: Part A – Annotated assembly design drawing for the gripper (A3 size) and a dimensioned drawing for parts in contact with steel billets (A3 size) Part B – Supporting design calculations and reflective notes (typically two sides of A4) Evidence submitted for marking: Part A – Annotated assembly design drawing for the gripper (A3 size) and a dimensioned drawing for parts in contact with steel billets (A3 size) Part B – Supporting design calculations and reflective notes (typically two sides of A4)
Date submitted by candidate	DD/MM/YY

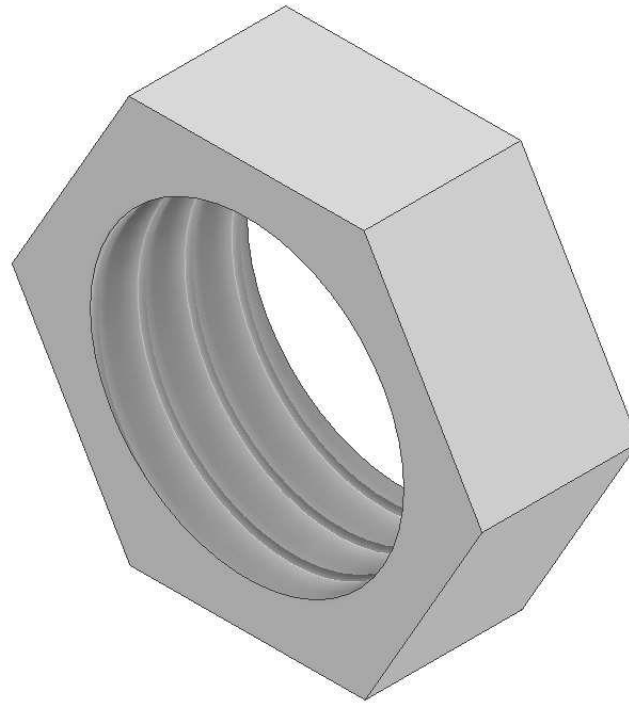


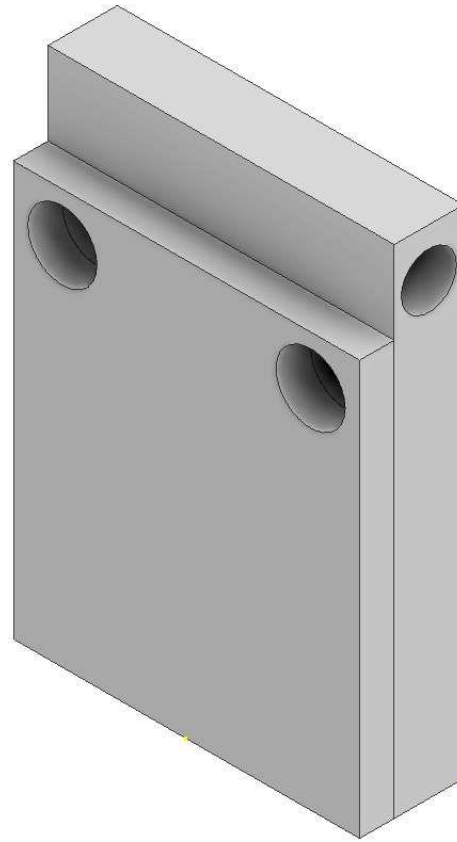














Calculations

Maximum weight the device can hold:

The linkages are held together with m10 bolts, M10 bolts with a grade of 8.8 can hold a maximum weight of 3,370kg. If I use a safety factor of 4, each bolt can hold $3,370/4 = 842.5\text{Kg}$ I intend to use one bolt to hold the frame to the base plate, so this bolt is holding the weight of the entire device and the hot metal billet. This may sound like a design flaw but since a regular m10 bolt can hold over 800kg there will be no risk of the bolt failing. I will need a bolt for the connecting piece as the bolt must go through a connecting piece of 50mm length and 4 linkages of 5mm thickness leaving room at the end for a nut. Thus, I will need a bolt like a coach bolt that is at least: $50 + (5 \times 4) + \text{room for bolt estimated } 15\text{mm} = 50 + 20 + 15 = 85\text{mm}$ length minimum.

M10 85mm bolts are available to buy in from a supplier.

So the maximum weight the device can hold is 842.5 kilograms which is well above what is needed for the application.

Device components:

4 linkages 100mm

4 linkages 150mm both 5 mm thickness mild steel

Two gripper hands

Base plate dimensions- 170mm radius 10mm thickness mild steel

Connector piece 50x50x30mm

M10 85mm bolt

M8 bolts standard

M10 bolts standard

M10 washers and nuts

I am assuming the linkages are a whole rectangular section for ease of calculation.

100mm linkages volume- $100 \times 14 (\text{width}) \times 5\text{mm} = 7000\text{mm cubed}$

There are 4 so- $7000 \times 4 = 28,000\text{ mm cubed}$

150mm linkages- $150 \times 14 \times 5\text{mm} = 10500\text{mm cubed}$

4x parts- $10500 \times 4 = 42000\text{mm cubed}$

Base plate = $\pi \times 170 \text{ squared} \times 10 = 907919.51\text{mm cubed}$

Connector: $50 \times 50 \times 20\text{mm} = 50000\text{mm cubed}$

Hands: $50 \times 70 \times 10 = 35000\text{mm cubed mild steel} \times 2 = 70000$

$50 \times 60 \times 10 = 30000\text{mm cubed zirconia} \times 2 = 60000$

Now I can add them all together for an estimate of the total volume of the gripper

$28,000 + 42,000 + 907,919.51 + 50,000 + 70,000 = 1,097,919.51\text{mm cubed}$ and the zirconia is left separately since it has a different density

The density of mild steel is approximately $\text{g mm}^3 = 0.0079 \text{ g/mm}^3$

If I multiply these two together it should give me an approximation for the total weight of the gripper.

$1,097,919.51 \times 0.0079 = 8673.564129\text{g}$ or 8.67Kg

This means that

When used vertically, the force acting on the gripper will be the weight of the bar-
The mass of the bar(16Kg) times the gravitational field strength on earth (9.81 N/Kg).
 $9.81 \times 16 = 156.96\text{N}$ of force that the bar will experience. So, the gripper must be able to hold or
clamp with at least 156.96N to hold the bar in place.

Does my design meet the standards of the brief-

I chose this design over others due to its superior cost and simplicity. The more complicated a design, the more that can go wrong. I find that my design sits in the sweet spot of being practical while being cheap, easy to manufacture, easy to maintain and low cost. It does not use an automated system like pneumatic actuators or electromagnet as it does not require them to operate, the automation is built into the design and function of the gripper. The use of its own weight and the weight of the bar to open and close the clamps mitigates the need for expensive systems like that of a hydraulic actuator. This design is large and strong enough to carry the bars and will divert a large majority of the heat away from the robotic arm, so I believe it is fit for purpose. Since my design will automatically pick up the bar, connects to the base plate of the robot with the correct dimensions via nuts and bolts, and will be capable of carrying them 3 meters

BOM- Bill of Materials-

Mild Steel 5mm thick 3m length.

Mild steel 10mm thick 3m length.

M10 bolts, M8 bolts, 85mm M10 bolts.

M10 nuts, M8 nuts.

zirconia plate 50x60x5mm

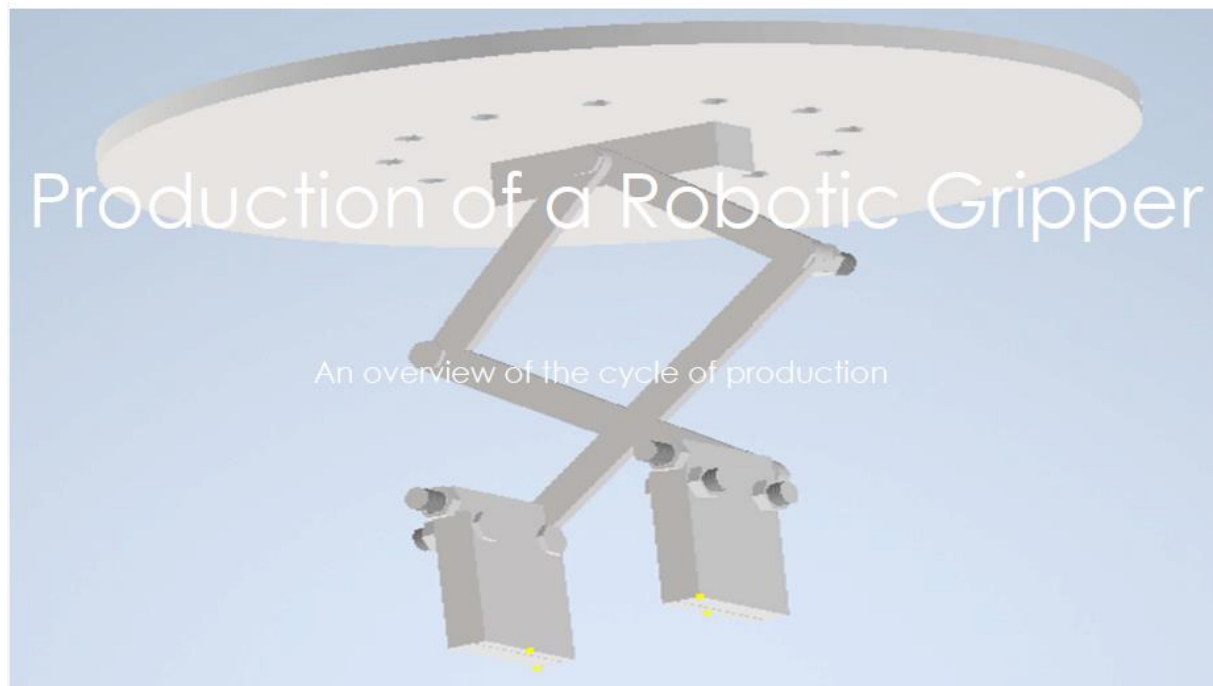
Task 4 Present

Assessment number (eg 1234-033)	8730-034
Assessment title	Employer-Set Project

Candidate name	<first name> <surname>
City & Guilds candidate No.	ABC1234

Provider name	<provider name>
City & Guilds provider No.	999999a

Task(s)	4
Evidence title / description	Evidence expected for marking: Presentation materials Evidence submitted for marking: Presentation materials
Date submitted by candidate	DD/MM/YY



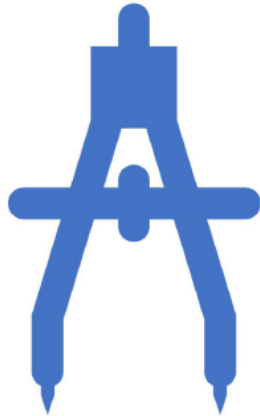
Production of a Robotic Gripper

An overview of the cycle of production



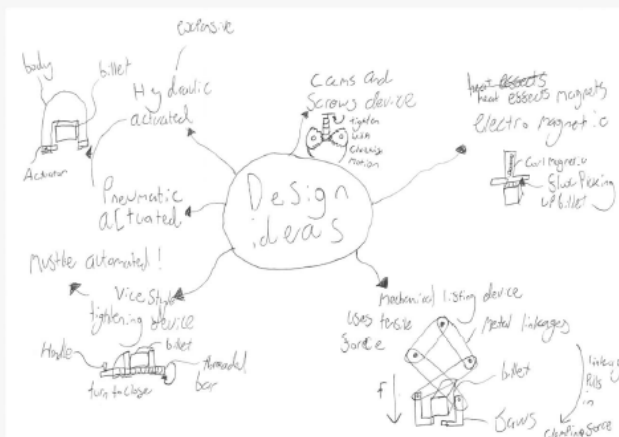
The Brief

- I was tasked to make a robotic attachment to carry hot billets.
- The billets are 50x40x1000mm, 16Kg and 600 degrees Celsius from the forge.
- They must be transported 3 meters between the forge and the dispatch area.
- The gripper must attach to the backing plate on the robot which is:
- 170mm radius with 12 holes 10mm in diameter on a pitch circle diameter of 150mm.



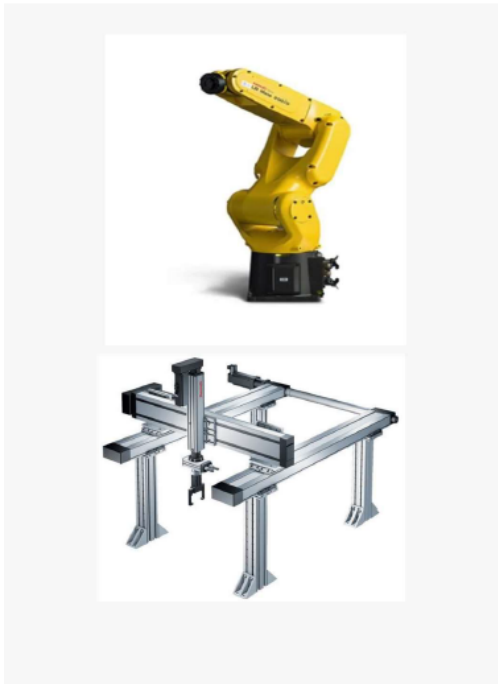
Task 1

- My first task was to research the project.
- I had to consider:
 - What will I be making?
 - What are some already existing designs?
 - What are the pros and cons of each design?
 - What robot will it be attached to as this will affect the design?
 - What materials should I use?



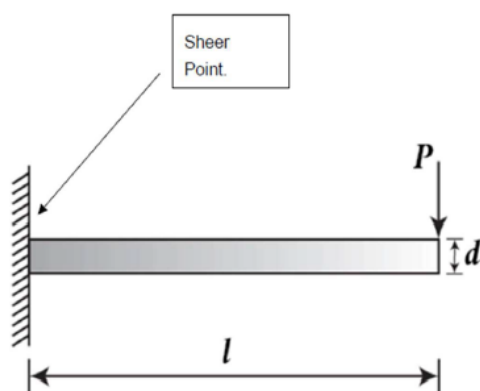
First Considerations

- I Created a Mind Map to help structure my thoughts
- I researched different mechanisms that can be used to pick up the billets
- I looked at the pros and cons of each and I liked how a mechanical based gripper and a pneumatic would work so I decided to research further.



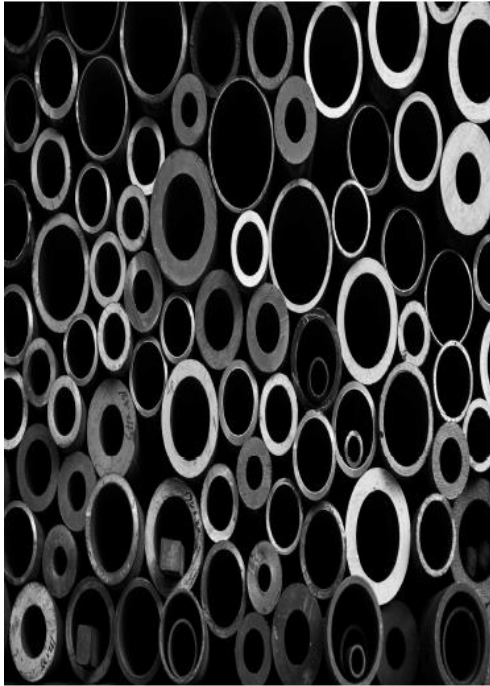
Difference in Robots

- There are two main robots that could be used for this application, six-axis and cartesian.
- Six-Axis can move in 6 axis, like a human arm they are very manoeuvrable.
- Cartesians can move in 3 axis, X Y and Z or left, right, up down and forwards backwards.
- For this application we need only move in 2 axis, forwards and backwards, up and down.
- My design assumes we are using a cartesian device.



Forces Involved

- If the device is positioned vertically or horizontally is very important to the design process
- If it is acting vertically, weight is the main force to consider.
- The mass of the bar (16Kg) times the gravitational field strength on earth (9.81 N/Kg) means a force of 156.96 Newtons.
- If it is acting horizontally, we must also consider bending moments and shear force, the arm will act as a beam.
- If we assume the arm is a meter long and we only consider the weight of the bar, the arm will experience a bending moment of 159.96Nm since moment is force x distance (156.96N x 1M)



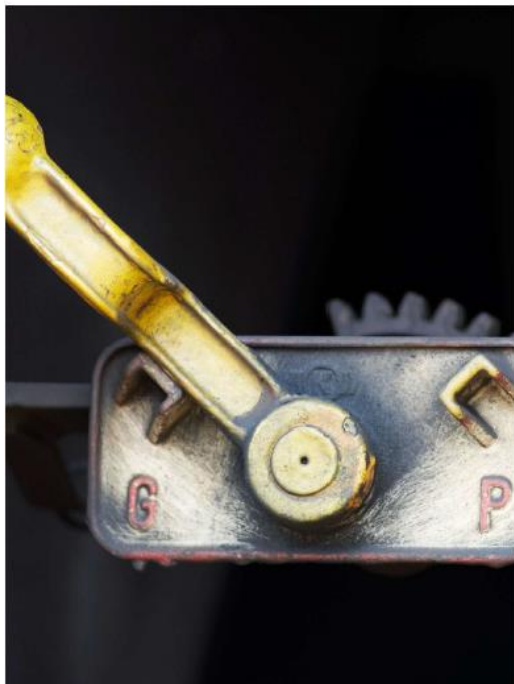
Pneumatic Devices

- For a pneumatic or hydraulic actuated device to work, it must achieve the force of 156.96N
- Example calculation of force applied by a small actuator-
- $F_1 = P \times A_1 = P \times (\pi/4) \times D^2 = 706.9 \text{ N}$
- Where pressure is a maximum of 10 bar(P) according to ISO 15552
- The diameter of the piston head is 30mm(D) and piston area is 706.9mm squared (A)
- A pneumatic option was viable but ruled out due to costing
- The most expensive consideration is installing a pneumatic system with an air compressor and tubing



Mechanical Devices

- These grippers work by using the weight of the load they are carrying and the tensile force to pull the mechanism outwards towards the closed position .
- Just like how a child's plastic claw toy would work.
- Because they don't use any automated systems they are much cheaper
- They still grip automatically as per the brief.
- I decided to pursue this approach.



Lean Manufacture and 'Future Proofing'

- The use of adjustable clamps is great for future proofing the design
- different billets of metal may become high demand and need carrying as needs of customers and supplier demands constantly change in the industry.
- Incorporating a future proofing into my design is a great way to save the company money in the long run not needing to change to different clamps for different applications.
- This is an example of lean manufacture.

What Materials are Suitable?

Mild Steel is one option

Mild steel has a relatively high melting point of between 1450°C to 1520°C which is well above 600 degrees Celsius.

Mild steel has a carbon content of 0.16% and 0.29 % and it is suitable for forging, cutting, drilling, welding and is easy to fabricate.

Mild Steel also has a relatively high tensile strength of 440 N/mm² (Megapascals) or 63,816.6 Psi (pounds per square inch) which makes it suitable for the application.

With a safety factor of 4 the linkages will be able to withstand 110 MPa safely.

16kg will be able to be carried safely if the gripper is to be made from mild steel.

- The most common type of stainless steel, 304, has a tensile yield strength around 210 MPa (30,000 psi) in the annealed condition.
- The melting point of stainless-steel ranges from 1,325 to 1,530 °C (2,417 to 2,786 °F) which is near that of ordinary steel.
- Stainless is much more expensive than mild steel, has a lower tensile strength and is difficult to fabricate with.
- its only advantage is its corrosion resistance, but mild steel can easily be painted or heat treated to prevent corrosion for a fraction of the cost.
- Therefore, I will use mild steel for the body.



Methods of Manufacture

- Fabrication- Using methods like cutting and welding to take raw material and make parts to assemble.
- Forging- Shaping pieces of metal by using heat and force to compress or flatten them into shape.
- This makes the product stronger but requires a high budget and specialist equipment.
- Casting- Melting metal and pouring it into a die (mould) to cast a specific shape which reduces wastage.
- However, this again requires specialist equipment, and this would majorly increase the price of the product unnecessarily.
- Wasting- Removing excess metal to cut out the desired shape often using a band or hacksaw.
- Additive- Building a piece layer by layer often using polymer in a 3d printer.
- This is often only used for models as polymer wouldn't be suitable for this project on account of its weak strength and poor heat resistance.
- A combination of wasting, fabrication and some fitting and assembly will be used.



Heat Considerations

- I could use an air cooling or liquid cooling system, but I feel this would over complicate the design and add unnecessary pricing to the project.
- A ceramic pad would work to distribute the heat from the direct contact of the hot billet as ceramic is a fantastic insulator with a high melting point.
- Moreover, ceramic is good under compression which fits the application as it will be compressed between jaws and the hot bar.
- The machine will have to be lubricated frequently for smooth operation.
- The high heat causes problems as I can't use a standard lubricant like WD-40 as it will just burn off.
- Therefore, a nonliquid, high temperature solution like 'Coppaslip' or powdered graphite must be used instead.



Reporting my Findings and Initial Design

- I then put my research to work and began formulating a design.
- I decided I would be making a mechanical gripper
- It would be made from mild steel with a ceramic plate
- It would work using the motion of the linkages and the weight of the body, arms and the bar to grip.
- The components would mostly be connected by nuts and bolts with washers.
- This allows for more free movement for the gripper to work.



More on the Mechanism

- The design works by using the weight of the metal and the clamps to act on the metal linkages which are arranged as such that they can pull downwards inwards at the same time.
- This applies force to the sides of the bar which acts against gravity pulling it down to prevent it from dropping.
- The device will lower with the jaws opening to allow the hot bar to fit, it will then start to lift at which the jaws pull in and grip the bar.
- As the bar is lifted, the jaws tighten and fully hold the bar in place until it is transported, placed on the floor, and released.
- This all works via arranged linkages like a scissor lift.
- This means that it requires no zero human input other than controlling the robot.
- This mechanism is great from a cost saving perspective considering the rising cost of electricity and the installation cost of a pneumatic or hydraulic system.



How I Will Create the Device

- I will be cutting individual parts from larger sections of black bar(mild steel).
- I will be drilling holes for bolts to go through to hold the framework and grippers together.
- I will need to create a base plate and then weld a piece to attach the base plate and the gripper.
- This insures full connection between the robotic arm and the gripper.
- I created a Safe Operating Procedure (SOP) that outlines this process.

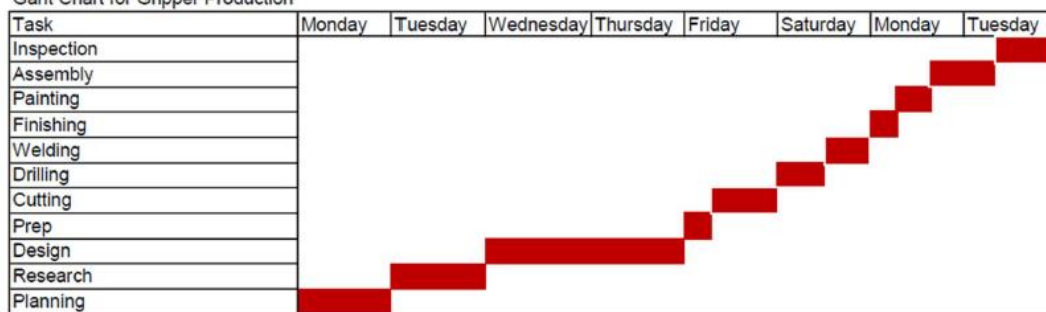
SOP



How Long Will Production Be?

- I created a Gant Chart to outline how long each procedure should take.

Gant Chart for Gripper Production



Maintenance and Health and Safety

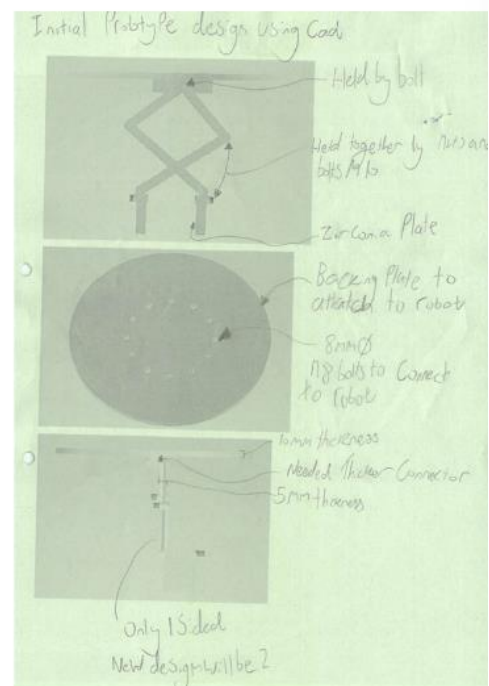
- 'Coppaslip' which is a brand name for a copper based powdered grease/ lubricant.
- The copper in the copper-based lubricant can be abrasive and cause wear so it would be more suitable to use the powdered graphite.
- I also painted the device to prevent corrosion and limit maintenance.
- I considered ease of maintenance so that the device can easily be lubricated.
- While other similar devices use covers around their bolts that fit into the frame mine does not.
- I can also cut channels into the linkages to allow for lubricant to be applied directly to the joints where the bolts are since these cannot be sprayed like WD-40 or other commonplace lubricants.
- I complied with general HASAWA (Health And Safety At Work Act) 1974 and subordinate acts
- Like PUWER 1998 (Provision and Use of Work Equipment Regulations)
- LOLER 1998(Lifting Operations and Lifting Equipment Regulations)
- ISO (International Organisation for Standardisation regulations for planning and design like ISO 9001.

Risk Assessment

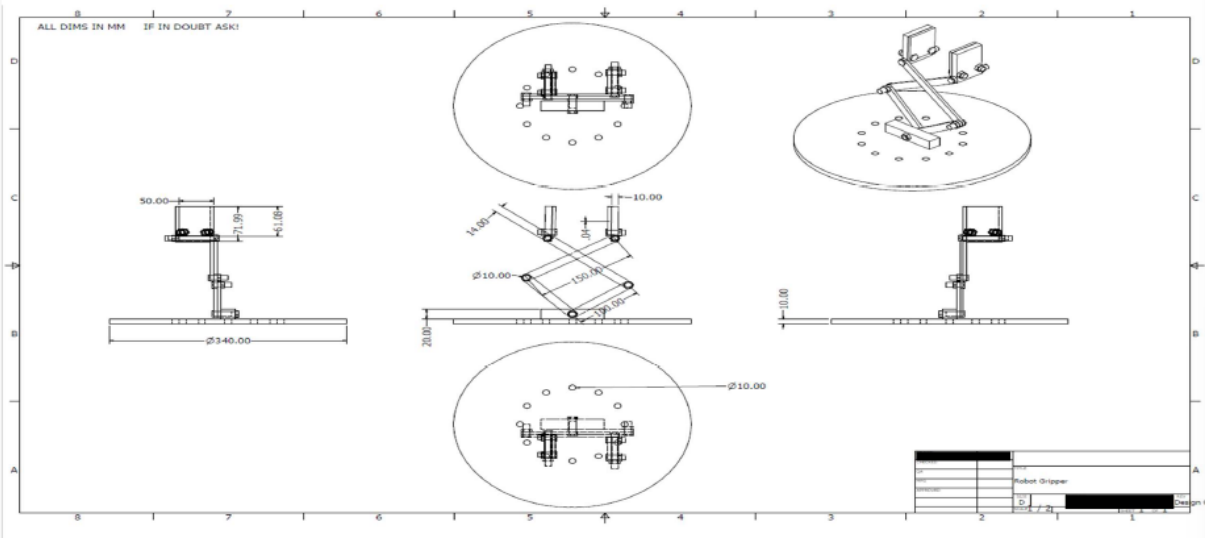
Activity/ Process/Operation	What hazards to health & safety exist?	Who might be harmed and how?	Exposure (A)	Consequence (B)	Risk Level (L X C)	Control measures in place to reduce the hazard?	Risk level after control H/M/L	Additional control measure required?	Risk level achieved H/M/L
Cutting	Cuts on fingers Debris flying off Sparks (grinder)	User and Passerby	3	4	12	Gloves Isolated room	H	Correct Signage	M
Welding	Arc flash burns electrocution	User and Passerby	4	5 4	20 16	goggles Welding mask Screening around welding area	M H	Separate welding bays Correct Signage	L
Drilling	Flying Shrapnel/ getting caught in the chuck/drift drilling	User and Passerby	3	5	15	guards with stoping Auto System.	M	No loose clothing/jewelry	L
Painting	Inhaling Paint Spumes getting paint in eyes	User and Passerby	3	3	9	Safety glasses dust mask	M	Using ventilation System	L

Final Design

- I created a prototype design on Cad and a final design on paper.
- I noted what went wrong and well and altered my final design accordingly.

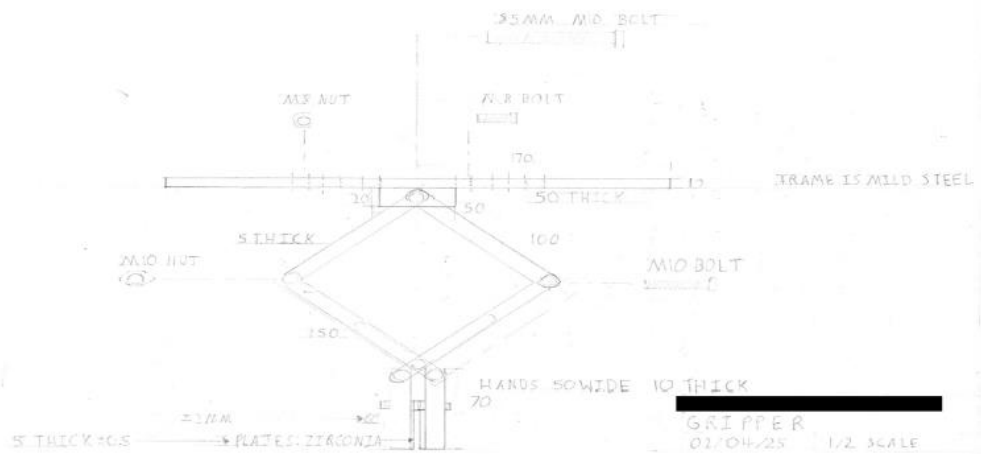


Concept Design 1



Evolution of my design

ALL DIMS IN M.M. IF IN DOUBT ASK



Challenges and Improvements

- Using CAD for my design was a difficulty and I would only hand draw next time.
- I frequently made incorrect angles of the linkages which lead to difficulty understanding the function of the design.
- Next time I could use an actuated system or a different mechanical system like a plate carrying clamp that uses locking cams

Employer-Set Project – Presentation Q & A Record (Task 4)

8730-13 T Level Technical Qualification in Engineering, Manufacturing, Processing and Control

8730-034 Employer-Set Project (Summer 2025)

Candidate name	<first name> <surname>
City & Guilds candidate No.	ABC1234
Date	DD/MM/YY

Provider name	<provider name>
City & Guilds Provider No.	999999a

Record observation notes below to inform external marking. **Notes must be detailed, accurate and differentiating.**

Tutor questions to candidate	Candidate responses
What did you find the most challenging aspect of the brief?	The design process as there was many options to consider. It was difficult to find something that is functional. Angles for linkages was challenging.
What methods of manufacture did you consider for the parts of the gripper?	Linkages cut out from standard 10mm flat bar (angle grinder & drilling). Base plate and connector plate – cutting & drilling. Everything bolted together. Ceramic cut to size from supplier.
What additional information would have been useful for us to have provided in the brief?	Type of robot as this has huge implications on the design.

Tutor signature	Date
	DD/MM/YY

If completing electronically, double click next to the 'X' to add an electronic signature once the record is **finalised**.

Get in touch

The City & Guilds Quality team are here to answer any queries you may have regarding your T Level Technical Qualification delivery.

Should you require assistance, please contact us using the details below:

Monday - Friday | 08:30 - 17:00 GMT

T: 0300 303 53 52

E: technicals.quality@cityandguilds.com

W: <http://www.cityandguilds.com/tlevels>

Web chat available [here](#).

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