

INCLUDED ON THE
KS4 PERFORMANCE TABLES

Candidate style work and commentary

OCR Level 1/Level 2

Cambridge National in
Engineering Design

J822

For first teaching in 2022 | Version 1

Unit R040 - Design, evaluation and modelling

ocr.org.uk/cambridgenationals

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About this resource

We have produced this resource using the [sample set assignment for Unit R040](#).

The aim of the resource is to help you understand how candidate work could be marked using the marking criteria.

Our senior assessors have created some sample candidate work and commentary. They have indicated the criteria that should be considered and how the marking criteria could be applied.





Please note this resource is for guidance only – it does not contain candidate work from an assessment series for this qualification and has not been through a standardisation process. The mark band awarded is only indicative of what similar work might receive. The resource also does not in any way indicate an endorsed approach to creating an NEA task and should not be used by students to submit as evidence.



Alongside this resource, we recommend that you view the sample assessment materials including the **command words**, to support your understanding.

Task 1: Product analysis

Product analysis

| Speaker | Aesthetics | Consumer needs | Cost | Environment | Size | Safety | Function | Materials and manufacture |
|---|--|--|---|--|---|--|--|--|
|  | This a cylindrical speaker which is available in a range of colours. This one is black with a mottled effect | This speaker is very small and would easily fit in your pocket. The controls would be difficult to access due to their size | The cost of the speaker is £6. This is probably too expensive for the quality of product, but suitable for a low income user | Due to its design, this speaker would suit a child's bedroom, or be carried around and use outside | The size of this speaker is 60mm x 65mm. | The casing is made of plastic and could shatter if dropped on a hard surface. All the parts are securely enclosed in the shell | It has 3W speakers which will provide adequate sound quality. The battery will only last a short period of time | The speaker will be ABS plastic and has been injection moulded. It has a PCB and LEDs for the interior lighting. |
|  | This speaker is an oval shape with a flat front and back. It is black with a sleek smooth appearance. | All the controls are located on the top of the speaker so easy to access. It is small and portable and would suit a young adult | The cost of this speaker is £130. Its quality of sound and technology increases the price | This speaker would suit a young adult or family home, probably a kitchen or bedroom. | The size of this speaker is 56mm x 127mm x 132 mm | The speaker is constructed of a soft touch silicone exterior. It has a smooth rounded shape | It is a high quality speaker with a long battery life. It is Bluetooth enabled and is water resistant | The speaker is constructed from a hard, rigid polymer but has a soft touch exterior which covers the whole speaker. It will be injection |
|  | This speaker is a cube shape with fabric outer lining and hard plastic top and bottom. The speaker is pink/red with a pattern mid- | All the controls are found on the top of the speaker and is simple to operate with supporting LEDs. A wrist strap allows the user to | The cost of this speaker ranges from £10-15. It is priced to be suitable for a younger target market. It is basic, but includes Bluetooth | The red speaker is more suited to a teenage bedroom or desk. It adds some interesting colour to a room | The size of this speaker is 104mm x 104mm x 107mm | The speaker has a soft fabric outer band around most of the speaker. It has rounded edges, both on top and bottom. The strap is a robust | It is a Bluetooth enabled with a built in FM ariel. It has 5W speakers and is wireless with a 10m range | The speaker casing is injection moulded with an inserted fabric body. It includes a LED circular ring and moulded buttons |
|  | This speaker is rectangular with a wood surrounding casing and steel front. It has a sleek and minimal design with craftsman | All the controls are found at the back of the speaker. It can be personalised for a gift. It can be used vertically or horizontally | The cost of this speaker is £300 and increases if personalised. The material is a higher quality | The personalised speaker would suit a family kitchen or work area, such as a desk or workstation | The size of this speaker is 100mm x 100mm x 200mm | The wood casing has been sanded to a smooth finish, but the front steel mesh could be sharp. It has rounded edges | It is Bluetooth enabled with a retro feel. It produces a deep natural acoustic sound. It can be used whilst charging | The speaker is constructed of Oak with dove tail joints and is treated with a Danish Oil finish. The grill is a steel mesh. |

Ranking matrix

| | Speaker 1 | Speaker 2 | Speaker 3 | Speaker 4 |
|--|-------------------------------|-----------|-----------|-----------|
| Ranking matrix | Rank 1- 5 (5 the best) | | | |
| Ergonomics (Shape, comfort, portability) | 3 | 4 | 3 | 3 |
| Aesthetic Appeal (Colour styling, shape) | 3 | 4 | 2 | 4 |
| Quality of Sound | 2 | 4 | 2 | 3 |
| Ease to control the speaker (buttons, volume) | 3 | 3 | 2 | 3 |
| Length of Battery charge | 3 | 5 | 1 | 3 |
| Sustainability (disassembly, recyclability, use of sustainable materials) | 3 | 3 | 4 | 3 |
| Totals | 17 | 23 | 14 | 19 |

ENGINEERING DESIGN – R040

PRODUCT ANALYSIS – RANKING MATRIX

Primary research

Primary Research

Questioning the view of a Bluetooth Speaker

In order to gain my primary research, I showed 10 people the speaker in the photograph. I asked them a number of questions, below are the questions I asked and the results.

Q1: Do you like the speaker?

Q2: Is the speaker portable?

Q3: Is the quality of sound adequate?

Q4: Does the speaker have suitable functions?

Q5: Does the price reflect the quality of the speaker?

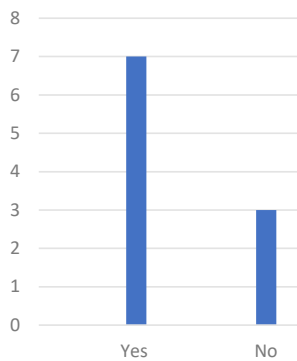


Is the quality of sound adequate

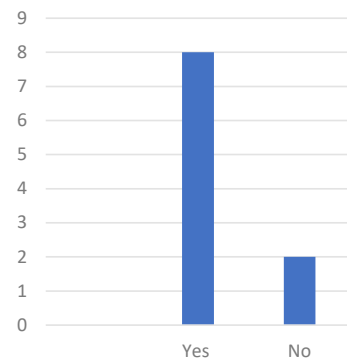


■ Yes ■ No

Do you like the speaker?



Is the speaker portable?

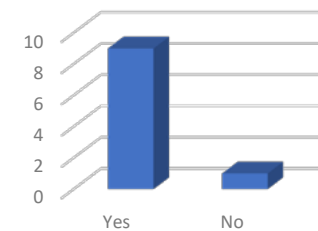


Does the speaker have suitable functions



■ Yes ■ No

Does the speaker reflect the quality of the speaker?



Commentary

The candidate has produced a table analysing four different music speakers. The table includes an image of each speaker and the ACCESS FM headings. The ACCESS FM analysis is reasonably detailed, and they have covered all the areas. However, the assignment brief also specifically asks for strengths and weaknesses to be identified.

The candidate has also produced a ranking matrix to score each of the music speakers. Each torch has been scored against a list of criteria and the highest scoring torch highlighted in yellow.

Even better if







To improve, the candidate could have:

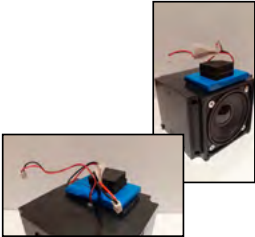




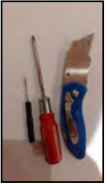
- given more objective commentary which was justified and reflective, such as explaining why the wrist strap would be useful, or why the portability of speaker 2 would suit young adults
- included further headings in the ranking matrix which reflect the ACCESS FM headings
- commented on how the ranking numbers were assigned.
- the candidate had reflected under the heading 'environment' on the grid for ACCESS FM, the material impact and manufacture of the products from cradle to grave and how this impacts the environment.

Looking to MB3

To move the work to MB3, the candidate could have expanded on their range of primary research and then summarised the results.

Task 2: Product disassembly

| | | | | | |
|---|---|---|--|--|--|
|  |  |  |  |  |  |
| <p>This is picture of the whole speaker, the AUX cable, the USB cable and the additional leather strap. The operational buttons can be found on the top of the speaker.</p> | <p>Firstly, I turned the speaker upside down and I used a screwdriver to unscrew the 4 cross head screws which held on the top section. They were covered by two white non slip based strips.</p> | <p>I removed the top section which allowed me to access the speaker. The top had four long extrusions which allowed the screws to screw into. This revealed the speaker, circuit board and battery.</p> | <p>The printed circuit board housed a number of different components, including the on/off switch, the USB socket, the AUX socket and other important microprocess which run the Bluetooth, AUX and FM stereo.</p> | <p>The speaker was connected to the circuit board by two sets of black and red wires. Each set of wires had a connecting socket. There was also a connecting socket from the battery to circuit board.</p> | <p>I laid the speaker on its side so I was able to slide out the speaker unit. The speaker unit was a moulded unit and the external casing was made from a red and black fabric.</p> |

| | | | | | |
|---|---|--|--|---|---|
|  |  |  |  |  |  |
| <p>The images shows the 5w speaker casing and the rechargeable battery. The black and red wire plug into the printer circuit board. The speaker casing was a solid plastic casing, probably manufactured by injection moulding. The parts were joined together in the middle.</p> | <p>The outer casing houses the printer circuit board, held in by two screws. The outer casing would have been injection moulded with a fabric cover glued on around the edge.</p> | <p>These images shows the top section which houses a ring which shows the LED. The four legs allow the assembly screws to locate so they can be screwed tightly. The buttons to move tracked onwards or backwards are moulded into the plastic. The LED board is screwed to underside of</p> | <p>This images shows the LED circuit board which is screwed to the underside of the top section. It lights up when the speaker is turned on. The cable runs down the side of speaker and slots into the printer circuit board.</p> | <p>The is an internal view of the plastic speaker which sits next to the speaker. The plastic my be ABS or Polyurethane. The holes allow the music to be heard from the speaker. The plastic is black and shiny with the fabric rapped around the edge.</p> | <p>These are the tools I used to disassemble the speaker. The craft knife was used pull back the none slip base. The cross head screwdriver and the flat head screw driver was needed to remove the screws.</p> |

Commentary

The candidate has produced a written table which demonstrates the disassembly of a commercial Bluetooth speaker. They have produced photographic evidence to show all the component parts of speaker and the complete disassembly of the product. Each photograph has supporting annotation detailing the different components, function, materials, manufacturing methods and assembly methods.

A **Teacher Observation Record** should be used to explain the level of assistance provided to the candidate during the product disassembly (Engineering Design specification Section 6.3.6 Teacher Observation Records).

Note, the candidate would not typically achieve a MB2 if the photographic evidence was limited and they did not provide enough supporting annotation evidence.

The candidate has photographed the tools used to undertake the disassembly and has been photographed undertaking the disassembly.

A **Risk Assessment table must be used** to demonstrate safe working practices. The Risk Assessment template should be completed by the student. The template is found in the [R040 set assignment sample assessment material](#).

Even better if

To improve, the candidate could have included a written procedure for the safe disassembly of the speaker. The candidate could also have added maintenance to the analysis headings. Further commentary could be more comprehensive. The plan should include the tools required and control measures, then a risk assessment which considers the relevant hazards and their associated risks.

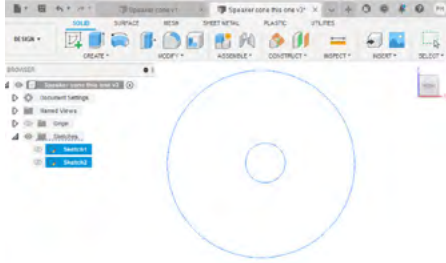
Looking to MB3

To move the work towards MB3, the candidate could include further annotation to explain how the speaker is manufactured, assembly methods, production methods, maintenance and a justification for the choice of materials.

Task 3: Virtual CAD 3D

Speaker cone

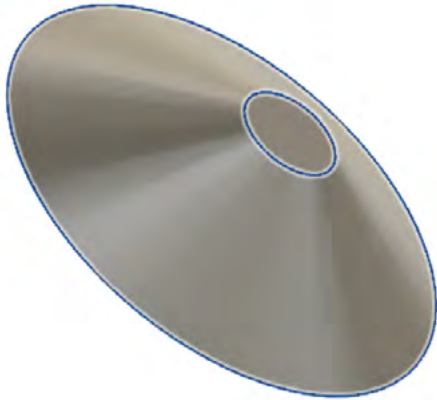
I began by sketching two circles of the correct size



I then moved one of the circles and used the loft command to make a solid cone



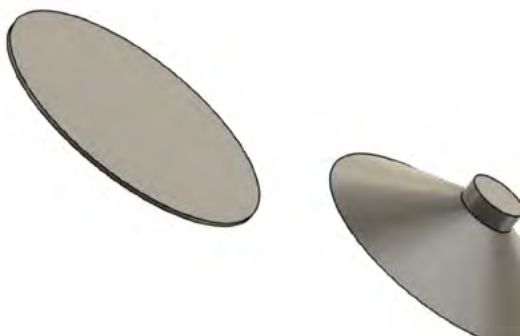
Then I used the shell command to make a hollow cone



Then I sketched and extruded the back of the speaker cone



Then I sketched and extruded the outside rim of the speaker



Then I used the hole command to make the correct size hole in the rim

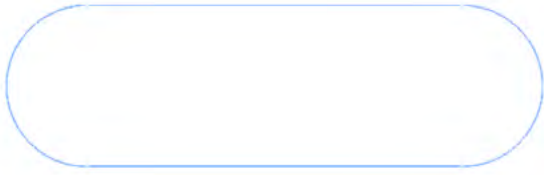


Then I joined the rim to the cone and made this into a component



Speaker base

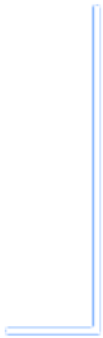
First I sketched the shape of the base



Then I extruded it to the correct height and rendered it to look like wood

**Speaker frame**

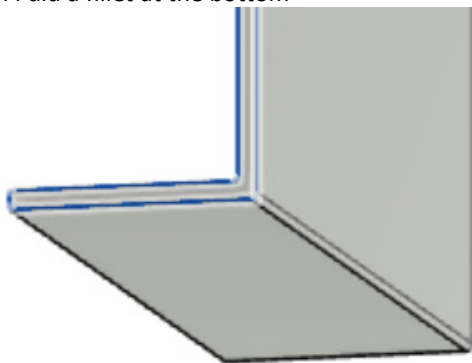
First I sketched the speaker



Then I extruded it



Then I did a fillet at the bottom



Then I did 2 fillets at the top



Then I made two holes in the face



Then I rendered it red glossy plastic



Volume button

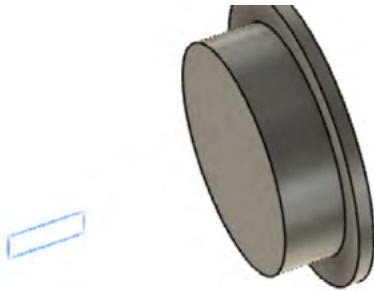
First I drew a sketch



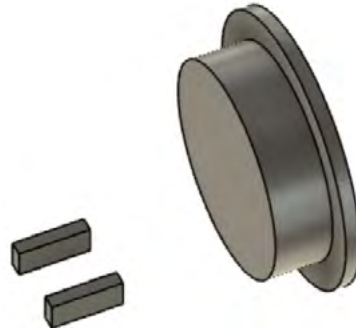
Then I used revolve to make the component



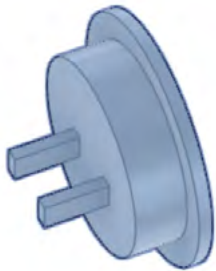
Then I sketched a pin for the back of the button



Then I extruded and copied the sketch

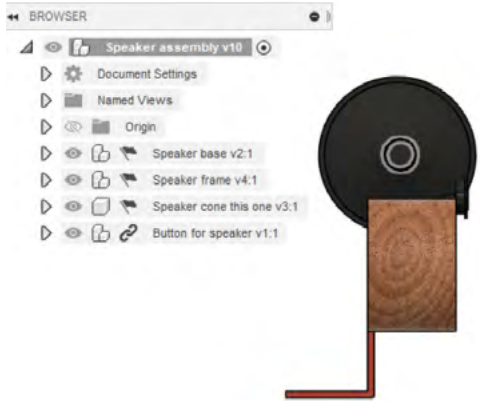


Then I joined the pins to the button and made it into a component and rendered it black gloss plastic

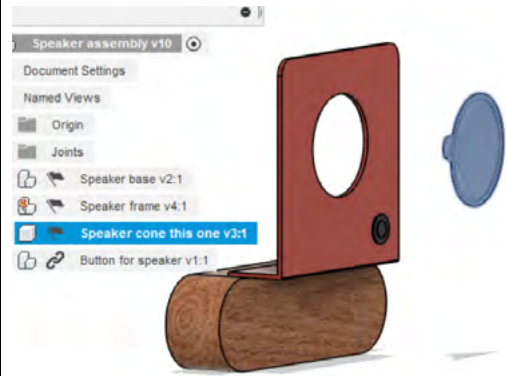


Assembly

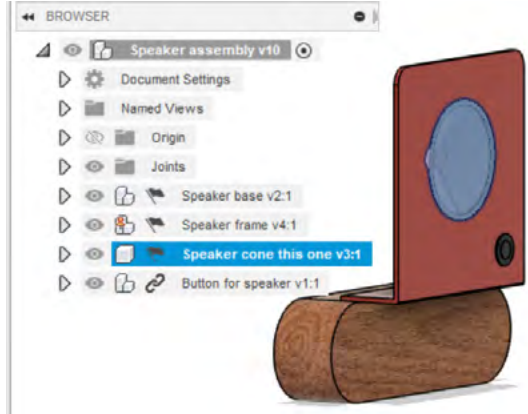
I imported my components



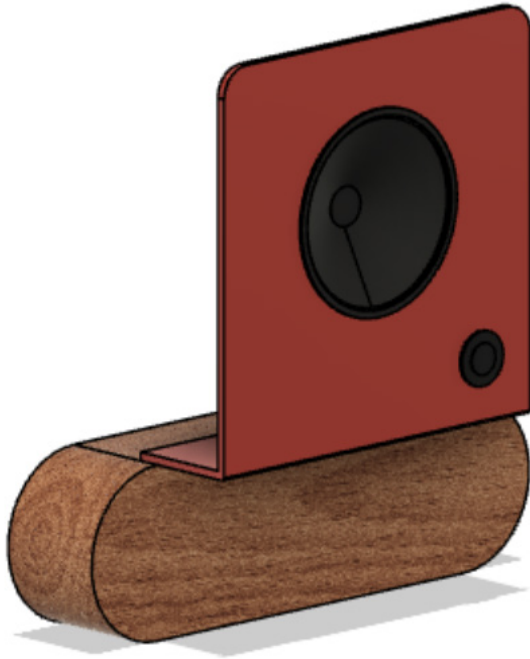
I joined the speaker frame to the base and the button to the speaker frame



Then I joined the speaker cone to the speaker frame



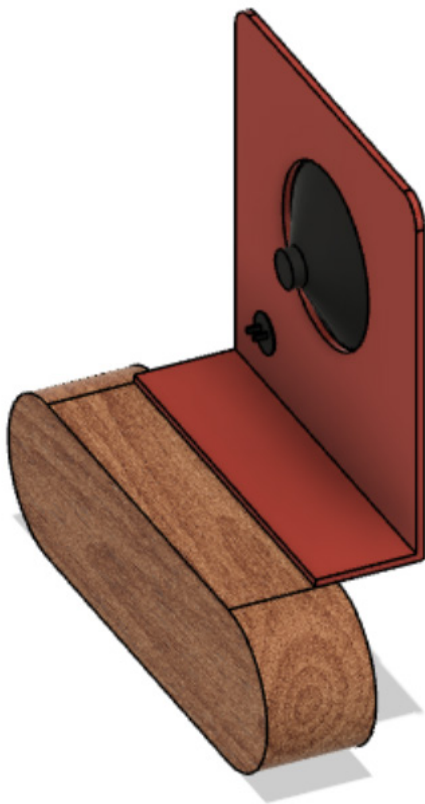
Front view



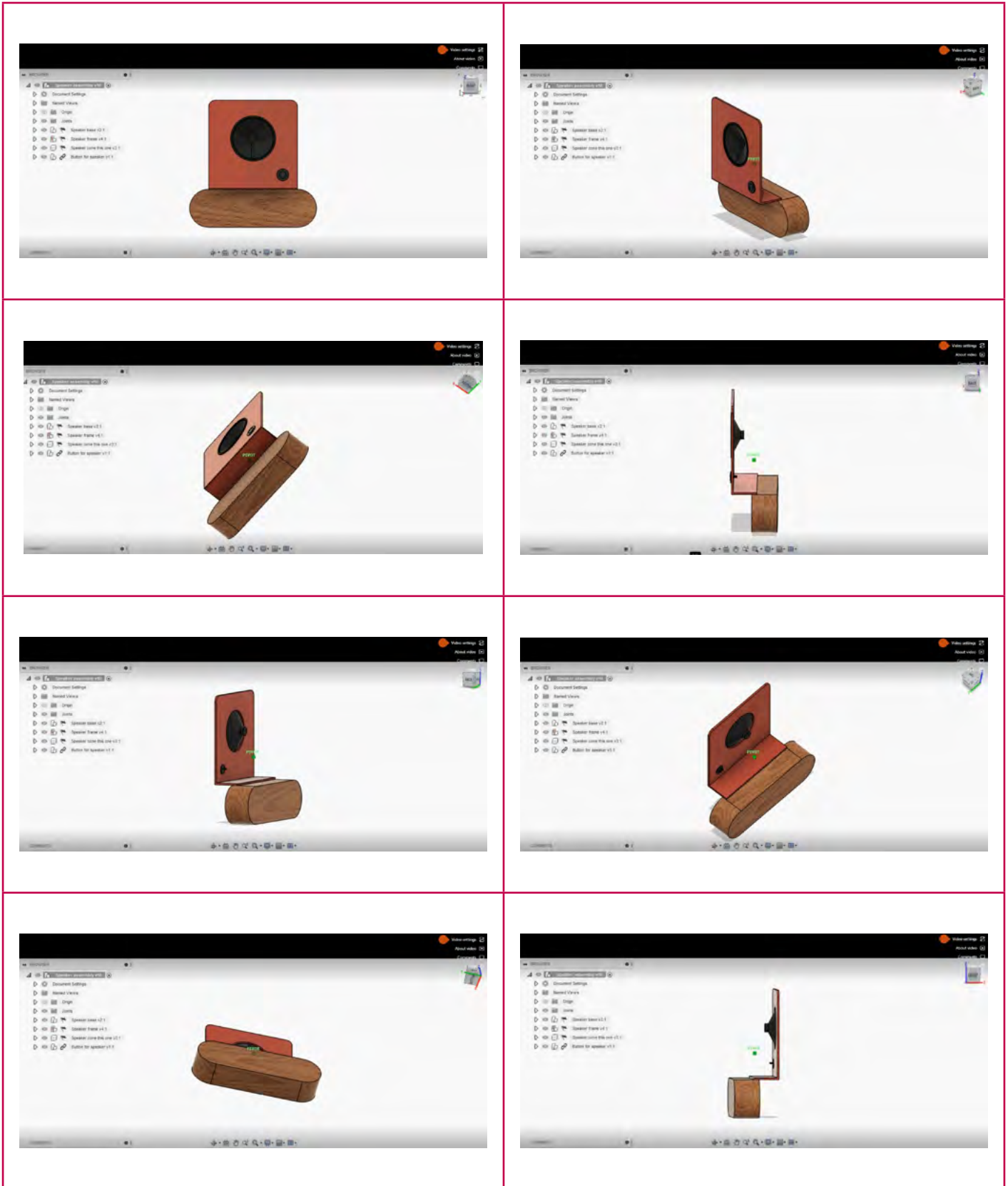
Rear underside view



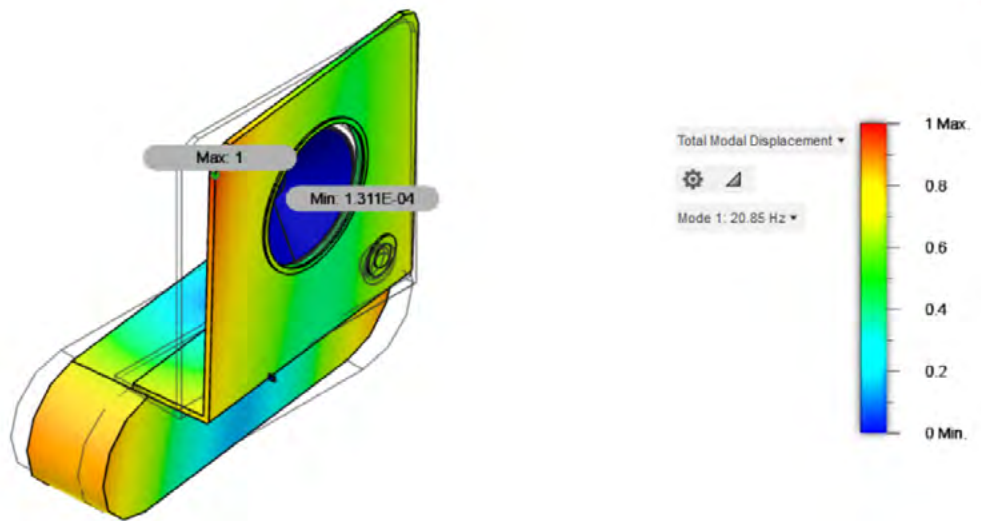
Rear view



Screenshots from the video showing the angles of the product



I ran a modal frequencies analysis of the speaker to simulate how it would work. I tested frequencies from 20 to 20kHz which is the range of frequencies humans can hear.



My analysis shows that the speaker will not perform well. The base will vibrate backwards and forwards and the speaker frame will shake loose.

Commentary

The candidate has taken the information from the music speaker orthographic drawing and created a series of separate component drawings. Each component has been drawn to the correct size and scale.

The candidate has produced a series of screen shots of their virtual CAD work showing the construction of individual components for the speaker. The series of screen shots show the construction of the components modelled in from a variety of angles. Although annotated with what is happening at each step the work is deemed **adequate** because while all of the individual components (with the exception of the screws) are shown, pertinent details, such as the dimensions of holes, are missing.

The candidate has used the software to render each component in a suitable material e.g. plastic, hardwood and aluminium.

The candidate then continues the series of screen shots showing the assembly of the components into a 3D model. This involved using different views in the model to rotate and move the components and join them as required. Again this is **adequate** because not all of the joints are mated; notably the speaker frame although touching the base is not actually mated to it and it is not correctly aligned. Also, the screws, indicated in the orthographic drawing, are not shown.

The candidate has used different views to position the components, so they are accurately aligned. Typically, this would not gain MB2 if there were limited and simple CAD evidence and the candidate was dependent upon others.

However, the candidate then followed this up with an appropriate complex industry related CAD activity, in this case modal frequency analysis. This is an appropriate CAD activity for this product because there are moving parts (e.g. speaker cone) however the appropriate CAD activity e.g. static stress, thermal stress, event simulation will depend on the product being designed. From this frequency analysis the candidate has described what the analysis shows about the operation. The analysis is mid MB2 because although the candidate has described what the analysis has shown they have not explained how they can tell this from the image or evaluated what this would mean in terms of real-life operation (i.e. the sound quality of the speaker, longevity of the speaker). The teacher observation record also indicates that the candidate required some assistance.

The candidate has shown operation of the 3D model by using motion to show the speaker cone moving back and forth short distances. In this case the candidate has demonstrated this process by inserting thumbnail images, but attaching a film animation of this process is also acceptable. They have not however added motion to the button. This alone would not constitute a complex industry related CAD activity and would not achieve more than MB1 and additionally.

A **Teacher Observation Record** must be used to explicitly explain the level of assistance provided to the candidate during the CAD production. ([Engineering Design specification](#) Section 6.3.6 Teacher Observation Records). This could also be used to indicate features, such as motion, that cannot be seen in the screenshots.

Even better if

To improve, the candidate could have used their virtual modelling 3D skills to soften some of the component edges. Further views could be added to show the completed speaker assembly. The candidate's description of what the modal frequency analysis shows would be strengthened simply by annotating the image to explicitly show how/where the image is indicating that the base is vibrating backwards and forwards and that the speaker frame is vibrating loose.

Looking to MB3

A key descriptor for MB3 is **comprehensive** so to move to MB3 it is essential that all components and aspects of the orthographic drawing are shown, likewise all joints and relative motions are included. The candidate could have also supported each screen shot with a commentary describing specifics, rather than a general overview response.

The candidate could also have evaluated how the vibrations shown by the modal frequency analysis would impact the operation of the speaker for the user (e.g. poor sound quality, might fall over/fall off surface, speaker frame will fall off base). Finally, to achieve MB3 the candidate must have worked independently and this will need to be verified by the teacher in an observation record.

Teaching tip

Producing many screen shots is the best way to provide candidate evidence for this task. However candidates often get so absorbed by the modelling process they forget to take regular screen shots. Many CAD applications produce a timeline of the design process and it is easy to use this to obtain the screen shots without undoing completed parts of the model.

Task 4: Physical modelling – production planning

Production Planning—R040

| Description of each Engineering Design practical task | Tool/equipment which will be used | Health & safety/PPE | How you will control the quality of the task | Time allowed to undertake the manufacturing task |
|---|---|---|---|--|
| I will start off the by using my orthographic drawing which I will then switch to the laser cutter which use to cut out the design. I will make sure my measurements are correct for my drawing so it is the correct scale. | Computer Printer 2D Design | | Before using the laser cutter I will make sure the measurement are to scale and review a print out | 30 minutes |
| Next, I will send my accurate drawing to the laser cutter making sure the lines will be red so the laser cuts out and not engraves. | Laser cutter | Make sure the extractor is turned on. | By making sure line are red and it cuts out and not engraves. Check the laser cut acrylic | 15 minutes |
| Next I will solder my resistors to my circuit board, then attach the capacitors, next I will add the switch and speakers | Soldering iron/stand Soldering wire Goggles Circuit component kit Mini extractor Pencil Ruler Orthographic drawing Vertical sander Try-square Tenon saw Bench hook | Use of an apron and safety glasses. Use a small extractor if available. Careful use of solder/irons | After I have soldered each component, I will check the soldered joint. I will test the circuit to ensure it works | 1–2 hours |
| I will use my orthographic drawing to help me check sizes for my base unit, then cut and shape my base | Pencil, ruler, orthographic drawing, vertical sander Apron, goggles | Follow RA for use of machines | Check the pine base dimensions against the orthographic drawing | 30 minutes |
| Once completed , I will sand down my base design to ensure the prototype is smooth. I will then add wax to surface to create high quality finish | Sand papers Wax Apron | Wearing an apron. Good room ventilation when applying wax. | Ensure the pine wood surface is smooth | 20-30 minutes |
| To finish off, I will attach acrylic top to the pine base, then glue in the speaker and push in the switch | Base Acrylic top Completed circuit Glue gun Apron | Safe use of glue gun. Wearing an apron. Use of safety glasses if appropriate. | Ensure the alignment between the acrylic top and base is correct, then accurately glue in the speaker | 20 minutes |

Commentary

The candidate has produced a table which maps out the various tasks required to create the portable speaker. The table indicates the description of each engineering design practical stage, tools, equipment and materials required to undertake the task, the health and safety/PPE requirements, the quality control procedures and an estimated time each task should take.

An alternative method for planning this task could have been by creating a Gantt Chart. It would allow the student to detail the processes and map the time allocation but would not provide sufficient planning information on its own.

Typically, the candidate would not achieve MB2 if the production planning document was limited and lacking detail or missing many of the important planning headings.

A **Risk Assessment table must be used** to demonstrate an understanding of safe working practices. The Risk Assessment template should be completed by the student. The template is in the [R040 set assignment sample assessment material](#).

Even better if

The table could also include some intermediate manufacturing stages such as setting up and using the laser cutter, making individual components and assembly of parts. There could be more views of assembly.

Looking to MB3

To move the work to MB3, the candidate could:

- add additional sheets to describe each stage with a greater number of intermediate stages.
- use a Gantt chart to support the written table to support time management
- include testing and evaluation checkpoints at key stages to make sure they are on track to complete the task successfully.

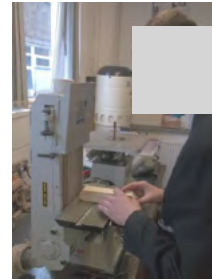
Task 5: Physical modelling – prototype production



The laser cutter is where I cut my acrylic to form the structure of my design



During this picture I am soldering the electronics and wires to my circuit board.



During this picture I am sanding a curve on my pine base. I am using goggles to protect my eyes.

ENGINEERING DESIGN – R040

PHYSICAL MODELLING – PROTOTYPE PRODUCTION



During this picture I am sanding my pine work with sandpaper to ensure its smooth.



During this picture I am waxing my pine to achieve a high quality finish.



During this picture I am using a hot glue gun to attach my speaker and circuit to my acrylic top piece. I then slotted my acrylic to the base.

ENGINEERING DESIGN – R040

PHYSICAL MODELLING – PROTOTYPE PRODUCTION

Commentary

The candidate has produced a record of the key stages of making the prototype model. The candidate uses annotated photographs to explain what they are doing in each of the practical stages although there is room for improvement in the evidence submitted. Students would be expected to document a better understating of health and safety through using images and annotation when making their prototype.

Typically, the candidate would not achieve a MB2 if there was limited photographic evidence or annotated explanations. Also, the candidate would not achieve a MB2 if tools and processes were used with limited effectiveness and the prototype was incomplete (i.e. there were limited links between the stages in the plan and the actual activities performed in the sequence).

A **Teacher Observation Record** must be used to explain the level of assistance provided to the candidate during the physical modelling prototype production. ([Engineering Design specification](#) Section 6.3.6 Teacher Observation Records.)

Even better if

To improve, the candidate could include more photo and/or descriptive evidence of the stages of making. This could include marking out, using different tools and setting up using CAD/CAM. The candidate could also review and justify available materials which they could use to prototype the portable speaker. If appropriate, the candidate could also provide evidence of the CAD drawing and add a photograph of the CAM 'in action' as a useful addition to the making review.



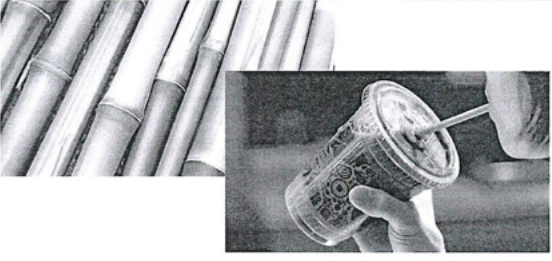
Looking to MB3

To move the work towards MB3, the candidate could give further and more detailed explanation about the purpose of the tools, equipment and machinery used.

Note - to achieve MB3, a candidate needs to work independently to achieve a highly effective outcome.

Task 6:

Physical modelling – evaluation of a prototype

| OCR Engineering Design: Unit R040 | Evaluation against the Product Specification |
|--|--|
| Product Specification | Comparison of your final outcome against the Product Specification |
| <ol style="list-style-type: none"> 1. Have a working circuit 2. Be aesthetically pleasing 3. Be a simple design that would allow large quantity production 4. Allow access to the battery so it can be replaced 5. Have good stability and is free standing 6. Be constructed from suitable materials for indoor and outdoor use 7. Have at least one speaker 8. Include a switch to turn the speaker on and off | <ol style="list-style-type: none"> 1) The speaker has a working mono circuit which plays out of one speaker. 2) My speaker is aesthetically appealing because the top and bottom section has a suitable shape which is pleasing to the eye. 3) The speaker has a two piece construction and joined together by standardised parts. If it was to be manufactured commercially, the top piece would be injection moulded and the base could be routed by CNC manufacturing. 4) The battery can be easily accessed from the back of the speaker. 5) The wood base is wide and allows for a very stable base. 6) The materials used would be most suitable indoors, however the acrylic is water resistant and the wood has a waxed finish. 7) My speaker has 1 speaker located in the middle of my design. 8) The speaker unit has a switch attached to the front face of the speaker and is easily accessible. The circuit wires are attached at the back. |
| Drawn design improvements | Explain the improvement |
|  | <ul style="list-style-type: none"> • Change the speaker shape so it is more aesthetically pleasing • Change the size of the base to improve the stability • Move the switch to the base so that design graphics could be added to the acrylic top |
|  | <ul style="list-style-type: none"> • Appeal to a wider range of people by changing the circuit to Bluetooth because new phones do not use AUX cables and it would be only appealing to a small audience |
|  | <ul style="list-style-type: none"> • Change the base and top materials to a more sustainable alternative. This would help with the disposal of the speaker when it has been finished with and needs to be disposed of. This could be bamboo and plant-based bio-plastics. |

Commentary

The candidate has evaluated their portable speaker against the initial design specification criteria. Some of the evaluation points have been justified.

There are three potential improvements with supportive justifications.

Typically, the candidate would not achieve MB2 if they did not review all of the design specification points, provide a limited response or did not suggest any improvements.

Even better if

To improve, the candidate could have provided a more comprehensive evaluation.

Looking to MB3

To move the work to MB3, the candidate could, for example:

- use photographs to help explain the evaluation comments
- question and present others' views to establish possible improvement area.

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