



Coimisiún na Scrúduithe Stáit State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2022

ENGINEERING – MATERIALS AND TECHNOLOGY

(Higher level – 250 marks)

THURSDAY, 9 JUNE

MORNING 9:30 – 12:30

The 2022 examination papers were adjusted to compensate for disruptions to learning due to COVID-19. This examination paper does not necessarily reflect the same structure and format as the examination papers of past or subsequent years.

INSTRUCTIONS

1. Answer **any five** questions.
2. All questions carry equal marks.
3. All answers must be written in ink on the answer book supplied.
4. Diagrams should be drawn in pencil.
5. Squared paper is supplied for graphs, as required.
6. Please label and number carefully each question attempted.

Question 1.

(50 marks)

Give **brief answers** to **any ten** of the following:

- (a) Outline **two** health benefits of using CO₂ monitors in classrooms.
- (b) Describe, with examples, the difference between amorphous structures and crystalline structures.



- (c) Describe the difference between a *clearance fit* and an *interference fit* in engineering limits and fits.

- (d) The single ratio gearbox motor shown opposite is suitable for model and light industrial applications and has a gear ratio of 100:1. Explain what is meant by 100:1 gear ratio motor.



- (e) Describe, with the aid of a diagram, how a pulley may be securely attached to the output shaft of the gearbox motor shown.

- (f) Discuss the contribution that **any one** of the following has made to technology:

(i) Nikola Tesla (ii) John McCarthy (iii) Alessandro Volta.

- (g) Explain **two** environmental benefits of using hydrogen powered fuel cell vehicles in modern urban transportation.



- (h) Explain the term *allotropy* in relation to iron.

- (i) Describe **two** benefits of applying plastic powder coating to mild steel frames.

- (j) Outline **one** method of reducing or eliminating the impact of any harmful fumes that may be created in the soldering of electronic circuits.

- (k) Identify **two** reasons for the use of titanium in the manufacture of sport equipment, such as in modern golf clubs, as shown.



- (l) Identify **one** advantage and **one** disadvantage of a gas shielded welding technique over a flux shielded welding technique.

- (m) Photovoltaic power stations (solar farms) contain a large array of solar panels, as shown, that supply electricity to the power grid. Outline **one** advantage and **one** disadvantage of solar farms in Ireland.



Question 2.

(50 marks)

Answer **all** of the following:

- (a) Industry 4.0 (4th industrial revolution) is a fusion of leading-edge production techniques and smart systems that integrate with organisations and people. An essential element of industry 4.0 is Artificial Intelligence (AI) and Smart Manufacturing.



- (i) Describe the term *Artificial Intelligence (AI)*.
- (ii) Explain the basic difference between *machine learning* and *deep learning*.

- (b) Artificial Intelligence can be broadly categorised in two forms. Describe the difference between:

- Artificial Narrow Intelligence (weak AI) and,
- Artificial General Intelligence (strong AI).

- (c) Explain **any two** of the following terms in relation to artificial intelligence and smart manufacturing:

- (i) Reactive machines;
- (ii) Limited memory;
- (iii) Theory of mind;
- (iv) Self-awareness.

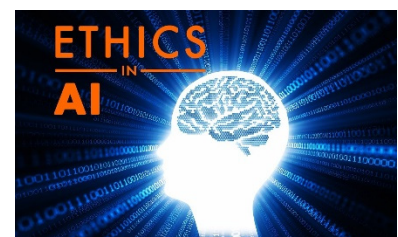


- (d) Artificial intelligence offers a range of benefits in smart manufacturing processes. Explain **any two** of the following in relation to smart manufacturing:

- (i) Predictive maintenance;
- (ii) Supply chain management;
- (iii) Quality control.

- (e) Artificial intelligence provides both benefits and concerns for the business and manufacturing industries. Discuss **each** of the following in relation to artificial intelligence:

- Economic benefits;
- Ethical concerns.



Question 3.

(50 marks)

(a) The engine crankshaft pictured opposite has failed due to metal fatigue.

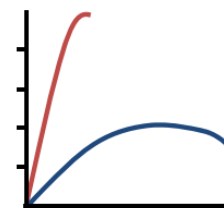
- (i) Explain the term *metal fatigue*.
- (ii) Outline **two** design considerations which will help minimise metal fatigue in the manufacture of crankshafts.
- (iii) Explain the importance of quality control (QC) in engineering manufacture.



(b) The results shown below were obtained from tensile tests on two metals, metal **A** and metal **B**.

Metal A	Stress (N/mm²)	125	260	400	425					
Metal B	Stress (N/mm²)	30	60	87	110	144	155	162	158	140
Metal A & B	Strain (x1000)	0.50	1.00	1.50	2.00	3.50	4.50	6.00	7.00	8.00

- (i) Using the graph paper supplied, plot the stress-strain diagram for metal **A** and the stress-strain diagram for metal **B** on the same graph axes, as shown opposite.
- (ii) With reference to metal **B**, describe with the aid of a diagram, the profile of the tensile test specimen when subjected to a load value of 158N/mm².
- (iii) Calculate Young's modulus of elasticity for metal **A** and Young's modulus of elasticity for metal **B**.



(c) In magnetic particle non-destructive testing (NDT) a portable magnetic device is used, as shown, for detecting imperfections in ferromagnetic materials.

- (i) Describe, with the aid of a suitable diagram(s), the process of magnetic particle testing.
- (ii) Outline **two** benefits of using NDT, such as magnetic particle testing, in the gas and oil industries.



magnetic particle test equipment

Question 4.

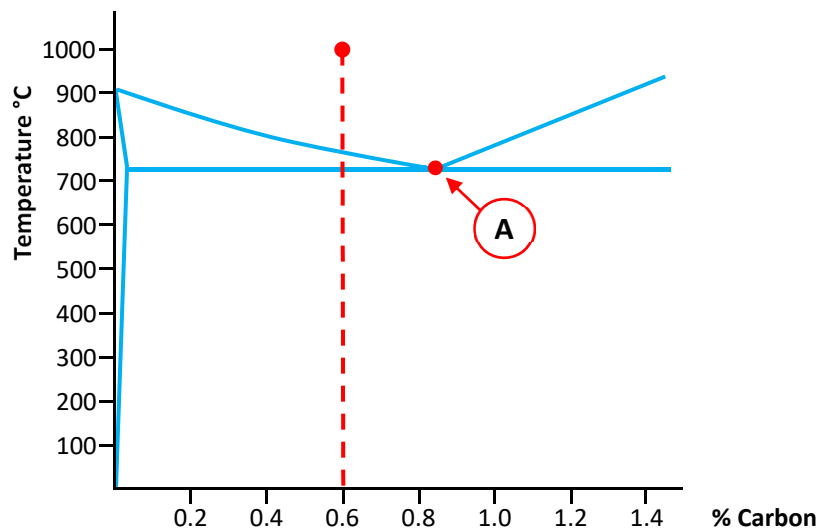
(50 marks)

- (a) The famous pedestrian Ha'penny Bridge which spans the river Liffey in Dublin is manufactured from a combination of cast iron and steel.

- (i) Explain **one** difference between cast iron and steel.
- (ii) Outline **two** reasons why cast iron was deemed suitable for the structure of the bridge.
- (iii) Give **two** other applications of cast iron.



- (b) A simplified portion of the iron-carbon equilibrium diagram is shown.



- (i) Identify the point **A**, and describe the transformation which occurs at this point.
 - (ii) Identify and describe the heat treatment process which occurs when 0.6% carbon steel is cooled very slowly from 1000°C, as indicated on the diagram.
 - (iii) Describe **one** method of accurately measuring furnace temperature when heat treating steel.
- (c) Induction hardening is a heat treatment technique that can be used to harden specific portions of gears to improve their mechanical properties.

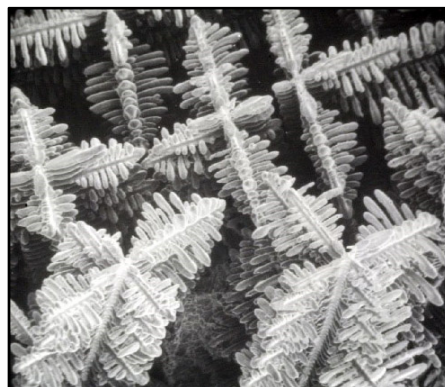
- (i) Describe, with the aid of a diagram, the heating and cooling process used in induction hardening.
- (ii) Outline **two** safety hazards associated with the induction hardening process.



Question 5.

(50 marks)

- (a) A microscopic image of the metal solidification process, dendritic growth, is shown.



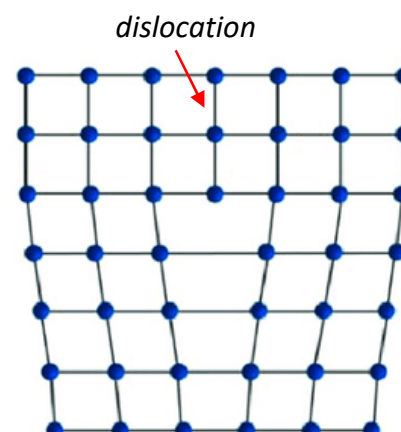
- (i) Describe, with the aid of diagrams, the process of dendritic growth.
- (ii) Describe, with the aid of a diagram, **any two** crystal point defects which may occur during the solidification process.

- (b) The table shows the solidification temperatures for various alloys of metal **A** and metal **B**.

% of metal B in the alloy	0	10	20	30	40	50	60	70	80	90	100
Start of solidification (°C)	1120	1225	1295	1345	1390	1420	1445	1468	1485	1495	1500
End of solidification (°C)	1120	1128	1150	1170	1195	1225	1260	1295	1350	1420	1500

Using the graph paper supplied:

- (i) Draw the equilibrium diagram according to the given data and label the liquidus and solidus lines.
 - (ii) For the alloy containing **70%** metal **B**, determine from the diagram the ratio of the phases at **1400 °C**.
 - (iii) State the melting point of metal **A** and the melting point of metal **B** in this alloy.
- (c) Select **any two** from (i), (ii) or (iii) below and explain:
- (i) The impact of a dislocation in crystal structures.
 - (ii) The possible corrosive effects of the environment on metal objects.
 - (iii) The refining of aluminium in Ireland.



Question 6.

(50 marks)

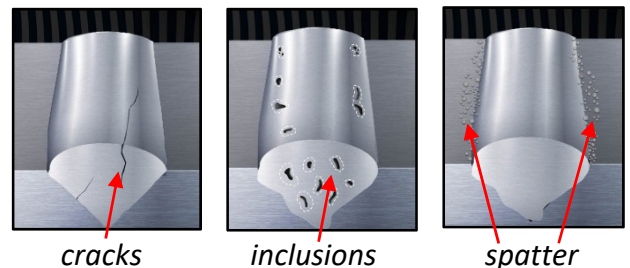
- (a)** The chassis of electric scooters is often constructed from lightweight industrial grade aluminium. Tungsten inert gas (TIG) welding may be used to fabricate the chassis.
- (i)** Describe, with the aid of a diagram, the process of TIG welding.
- (ii)** Explain **two** reasons for using TIG welding in fabricating industrial grade aluminum.



- (b)** Answer **any three** of the following:
- (i)** Outline **three** functions of the electrode coating in manual metal arc welding.
- (ii)** Explain **two** safety hazards associated with resistance spot welding.
- (iii)** Describe the principles of operation of a step-down transformer in welding.
- (iv)** Outline the function of a *consumable bare wire electrode*.

- (c)** Welding defects include cracking, slag inclusions and spatter.

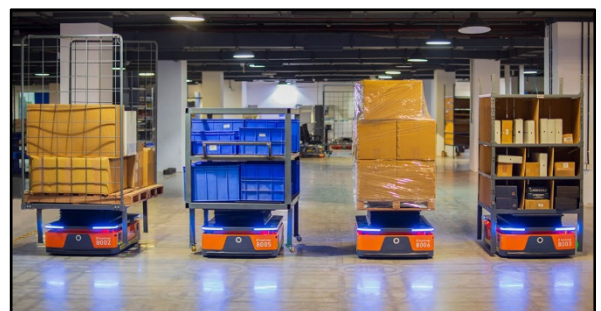
- (i)** Outline how weld cracks **and** slag inclusions may form on a weld.
- (ii)** Describe the effects of either cracks **or** spatter on weld strength and finish.



OR

- (c)** An autonomous mobile robot (AMR) is a vehicle that uses on-board sensors and processors to autonomously move materials without the need for physical guides or markers.

- (i)** Explain the following terms in relation to the autonomous mobile robots (AMR):
- Automatic charging zones;
 - 24-hour remote monitoring.
- (ii)** Outline **two** benefits of autonomous mobile robots (AMR) in warehouse operations.



Question 7.

(50 marks)

- (a) Bicycle helmets are manufactured from a range of thermoplastic polymers. The shell is generally manufactured from polyethylene terephthalate (PET) and the liner from expanded polystyrene (ESP).

- (i) Describe, with the aid of a diagram, a suitable thermoplastic manufacturing process for the polyethylene terephthalate (PET) shell.
- (ii) Give **two** properties of expanded polystyrene (ESP) which make it suitable for use in the helmet liner.
- (iii) Select a suitable polymer for the manufacture of the chin straps on the bicycle helmet. Justify your selection.



- (b) Answer **any three** of the following:

- (i) Outline the function of a *catalyst* in the addition polymerisation process.
- (ii) Explain, with an example, the term *copolymerisation*.
- (iii) Name **any two** polymer additives which are used in the production of mobile phone covers.
- (iv) Outline **two** environmental benefits of promoting widespread recycling of mobile phone covers.
- (v) Describe, with the aid of a diagram(s), the main differences between linear and cross-linked chains in polymers.



- (c) A range of plastic materials and glass are often used in the manufacture of mobile phone protective screens. Screen protectors may be laminated and tempered.

- (i) Compare glass and polycarbonate as suitable materials in the production of mobile phone screen protectors, making reference to:
 - impact resistance
 - transparency
 - hardness.
- (ii) Describe the process of polymer *lamination*.



laminated and tempered screen

Question 8.

(50 marks)

(a) Cutting fluids are used in a range of engineering machines.

- (i)** Name **two** types of cutting fluid.
- (ii)** Explain cutting fluid *rancidity*.
- (iii)** Outline **two** reasons for using cutting fluids in machining operations.



(b) Answer **any three** of the following:

- (i)** Outline, with examples, the difference between a 3-jaw self-centring lathe chuck and a 4-jaw independent lathe chuck.
- (ii)** Describe the term *interlocking guard* in relation to engineering machines.
- (iii)** Explain how the size of a drill bit affects the spindle speed of a lathe.
- (iv)** Identify **two** benefits of using a step cone drill bit as shown.
- (v)** Describe the importance of electrical isolating switches in the engineering room.



(c) Horizontal bandsaws are often used to cut metals efficiently in modern engineering rooms.

- (i)** Outline **three** safety features integrated into the design of a modern horizontal bandsaw.
- (ii)** Describe, with the aid of diagram(s), a method of securely clamping metals in a horizontal bandsaw.



OR

(c) Computer Numerical Control (CNC) machining is a manufacturing process in which pre-programmed computer software controls the movement of tools and equipment.

- (i)** Explain, with the aid of a diagram, the term *3-axis CNC machining*.
- (ii)** Describe the following CNC terms:
 - Simulation;
 - Tool offsets.



Question 9.

(50 marks)

- (a)** A worm and worm gear mechanism is often used in stringed musical instruments, such as cellos and guitars, to tension the strings to their correct pitch.

- (i)** Describe, with the aid of a diagram, the operation of the worm and worm gear in the tensioning of the strings.
- (ii)** Discuss **two** advantages of using this mechanism in the musical instrument shown.



- (b)** Answer **any three** of the following:

- (i)** Outline the function of the *fulcrum* in relation to levers.
- (ii)** Describe an energy conversion that takes place in a car battery.
- (iii)** Describe, with the aid of a diagram, the operation of a bevel gear system.
- (iv)** Explain **one** method of converting rotary motion to reciprocating motion.
- (v)** Distinguish between spur gears and helical gears.

- (c)** The all-terrain vehicle (ATV) shown opposite, features a variable speed rear wheel drive transmission and a *LifeGuard®* safety roll bar.

- (i)** Describe, with the aid of a diagram, a suitable variable speed drive mechanism for the ATV.
- (ii)** Identify **two** benefits of using a *LifeGuard®* safety roll bar on an ATV.



OR

- (c)** “Qi” is the wireless charging standard widely adopted by the largest and most well-known technology manufacturers in the world.

- (i)** Describe the basic principles of wireless charging.
- (ii)** Outline **one** advantage and **one** disadvantage of wireless charging electronic devices.



Leaving Certificate – Higher Level

Engineering – *Materials and Technology*

Thursday 9 June

Morning 9:30 – 12:30



Leaving Certificate Examination, 2022

Engineering - Practical (150 marks)

Morning: 10:00 to 1:00 - Afternoon: 2:00 to 5:00

Please Read Carefully

Instructions

- (a) The Examination Number must be clearly stamped or engraved, by the **teacher**, on the test-piece in the position indicated on the examination paper - 2022. M74A(L₂).
If the test-piece is not assembled, the Examination Number must be indicated on each separate part of the test-piece.
- (b) Candidates are not permitted to communicate with or assist one another.
- (c) Write your Examination Number in the box provided on the examination paper - 2022. M74A(L₁).
- (d) Put the examination paper - 2022. M74A(L₁) and the test-piece into the candidate envelope supplied, and hand up the envelope to the Superintendent at the end of the examination.

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7	Aluminium	Mark out, drill and shape.
10	Brass	Mark out, drill and shape.
12	Aluminium	Mark out, drill, tap and shape.

Note: (i) Parts 1, 2, 3, 4, 5, 8, 9, 11 and 13 have been made prior to examination day.
Using the screws supplied assemble the mechanism, as detailed on the assembly drawing.
(ii) **Accuracy, finish and function are important.**



Scrúdú na hArdteistiméireachta, 2022

Innealtóireacht - Praiticiúil
(150 marc)

Maidin: 10:00 go dtí 1:00 - Tráthnóna: 2:00 go dtí 5:00

Léigh na Treoracha seo go cúramach le do thoil

Treoracha

- (a) Ba chóir don **mhúinteoir** Scrúduimhir an iarrthóra a stampáil nó a ghreanadh ar an triailphíosa san ionad a thaispeántar ar an scrúdpháipéar - 2022. M74A(L₂). Mura bhfuil an triailphíosa curtha le chéile, ní mór an Scrúduimhir a thaispeáint ar gach páirt ar leith den triailphíosa.
- (b) Níl cead ag iarrthóirí a bheith i gcumarsáid le chéile ná cúnamh a thabhairt dá chéile.
- (c) Scríobh do Scrúduimhir sa bhosca atá ann di ar an scrúdpháipéar - 2022. M74A(L₁).
- (d) Cuir an scrúdpháipéar - 2022. M74A(L₁) agus an triailphíosa isteach i gclúdach an iarrthóra atá curtha ar fáil, agus tabhair an clúdach don Fheitheoir ag deireadh an scrúdaithe.

As na hábhair a sholáthraítear, déan an **Mheicníocht** a thaispeántar sna líníochtaí sa chruth agus sna toisí a shonraítear.

PÁIRT	ÁBHAR	PRÓISEAS
6	Polacarbónáit thrédhearcach	A mharcáil amach agus a dheilbhiú.
7	Alúmanam	A mharcáil amach, a dhruileáil agus a dheilbhiú.
10	Prás	A mharcáil amach, a dhruileáil agus a dheilbhiú.
12	Alúmanam	A mharcáil amach, a dhruileáil, a tapa agus a dheilbhiú.

Nóta: (i) Rinneadh na páirteanna 1, 2, 3, 4, 5, 8, 9, 11 agus 13 roimh lá an scrúdaithe. Agus tú ag baint úsáide as na scríonna a sholáthraítear, cóimeáil an mheicníocht faoi mar atá sa líníocht chóimeála.

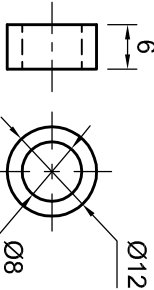
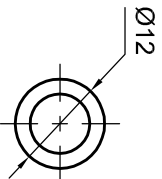
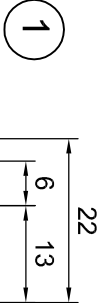
(ii) Tá tábhacht ag baint le cruinneas, le bailchríoch agus le hoibriú an triailphíosa.



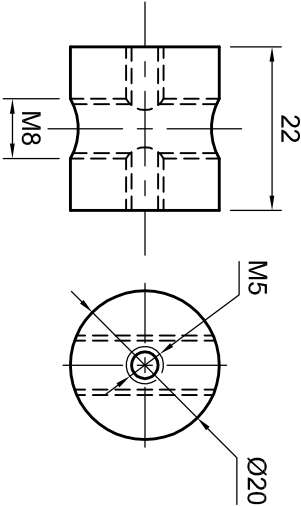
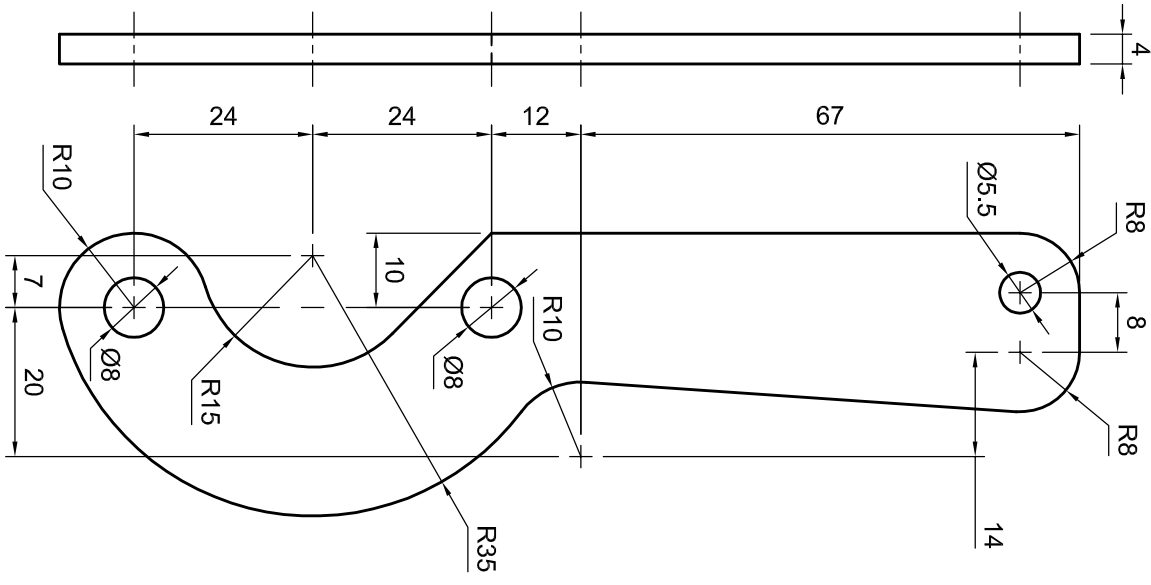
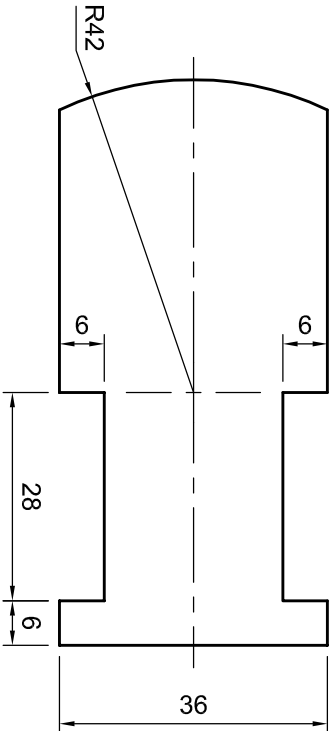
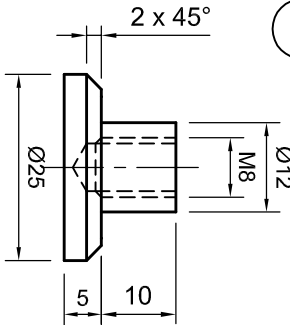
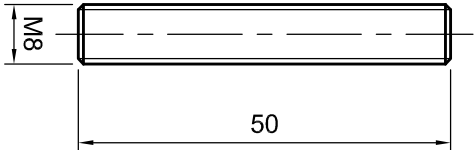
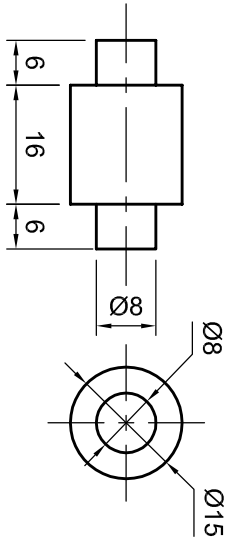
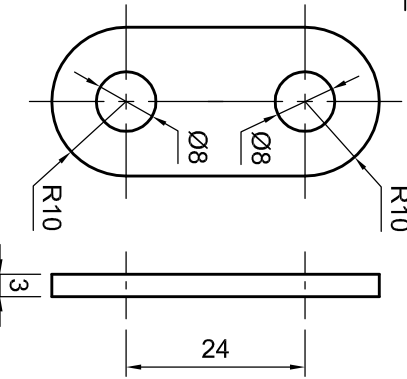
Cuir an scrúdpháipéar seo agus an triailphiosa isteach i gclúdach an iarthóra
atá curtha ar fáil, agus tabhair an clúdach don Fheithneoir ag deireadh an scrúdaithe.
Put this examination paper and the test-piece into the candidate envelope supplied,
and hand up the envelope to the Superintendent at the end of the examination.

Scriobh do Scrúduitheoir sa bhosca seo:

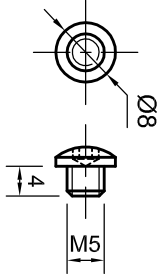
Write your Examination Number in this box:



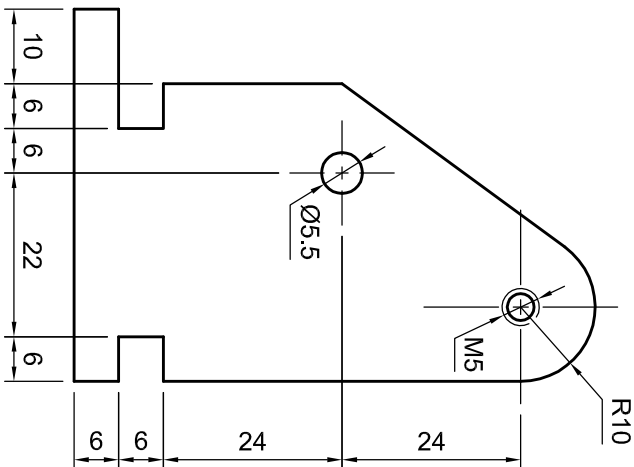
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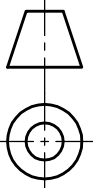
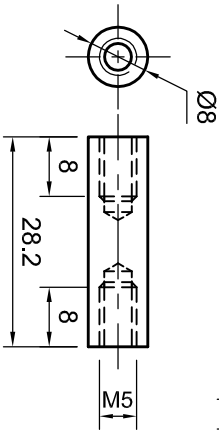
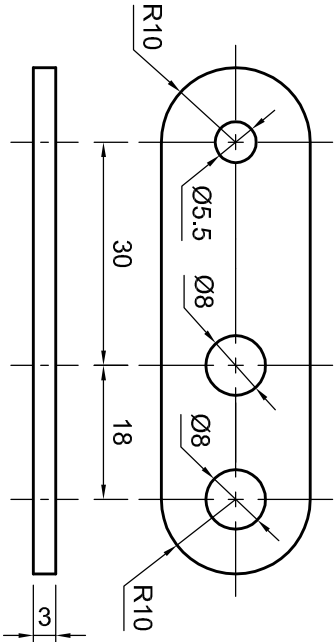
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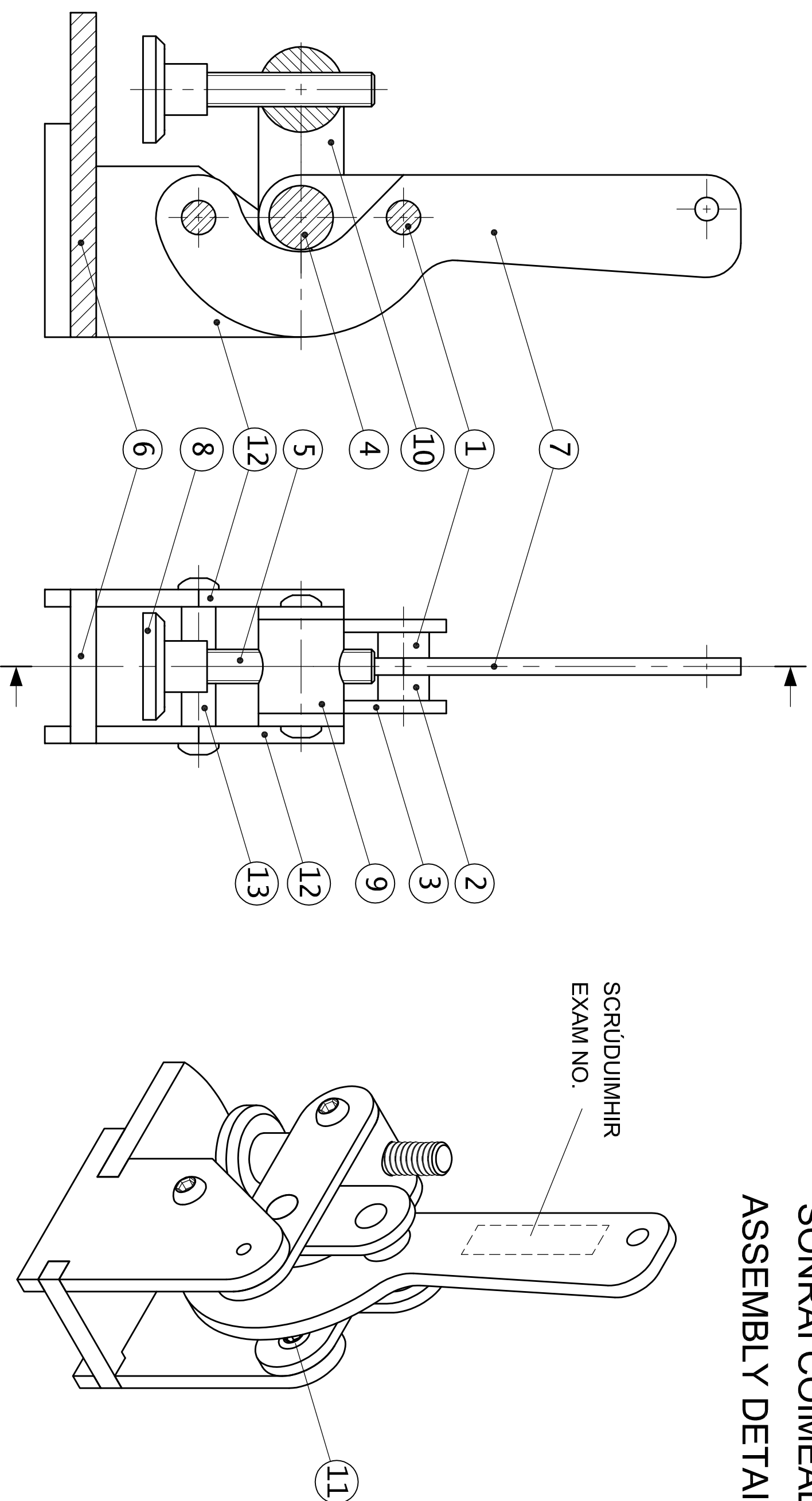
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SCRÚDÚ ARDTEISTIMÉIREACHTA - INNEALTÓIREACHT PRAITICIÚIL
LEAVING CERTIFICATE - ENGINEERING PRACTICAL

SONRAÍ CÒIMEÁLA
ASSEMBLY DETAILS



Cuir an scrúdpháipéar seo agus an triailphíosa isteach i gclúdach an iarthóra
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7	Aluminium	Mark out, drill and shape.
10	Brass	Mark out, drill and shape.
12	Aluminium	Mark out, drill, tap and shape.

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Nóta: (i) Rinneadh na páirteanna 1, 2, 3, 4, 5, 8, 9, 11 agus 13 roimh lá an scrúdaithe. Agus tú ag baint úsáide as na scríonna a sholáthraítear, cóimeáil an mheicníocht faoi mar atá sa líníocht chóimeála.

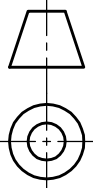
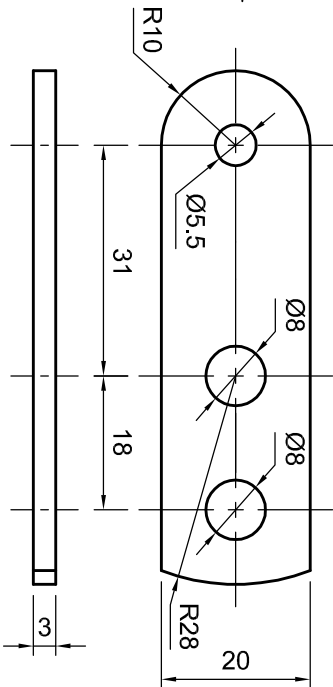
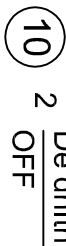
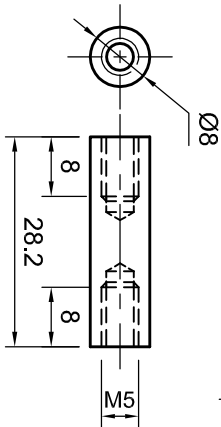
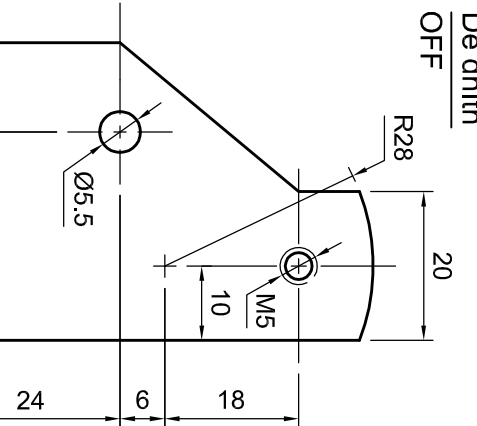
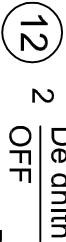
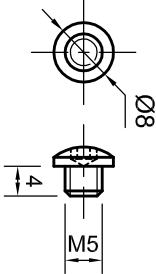
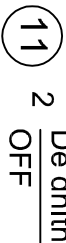
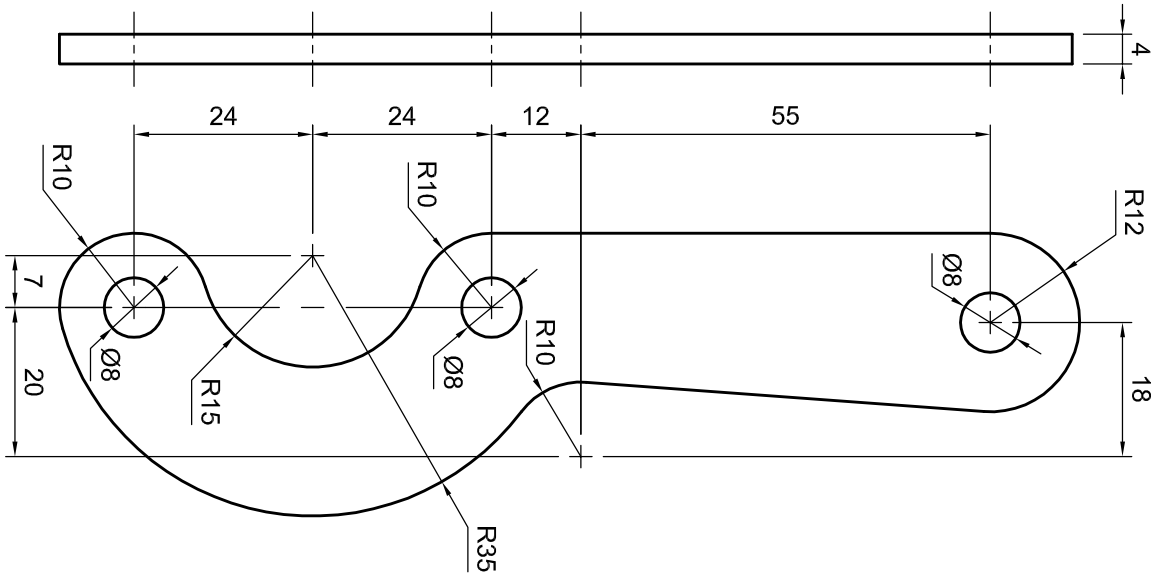
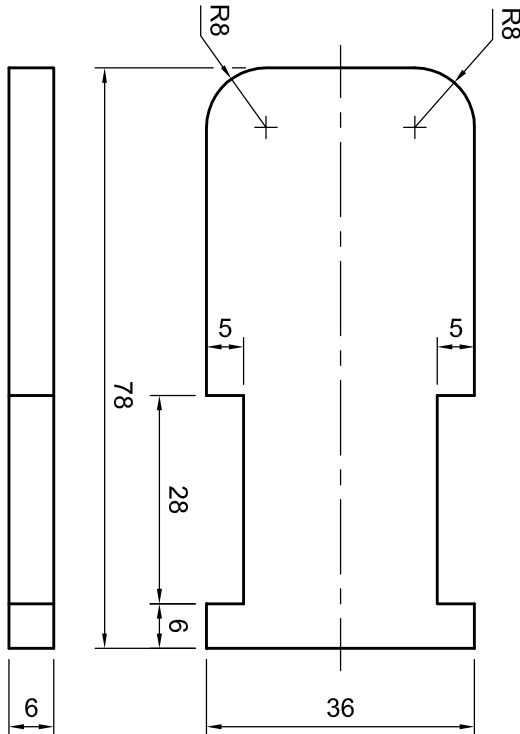
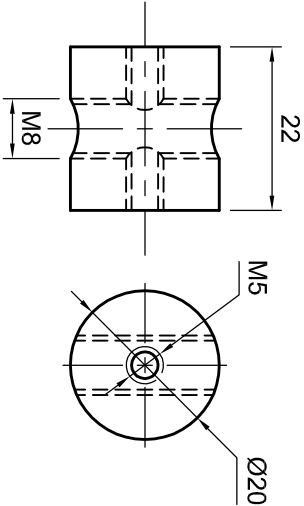
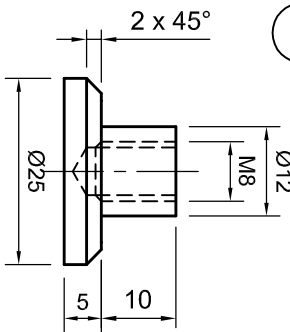
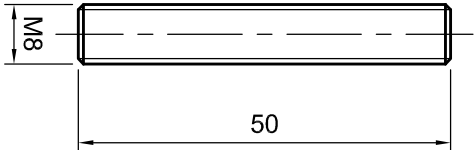
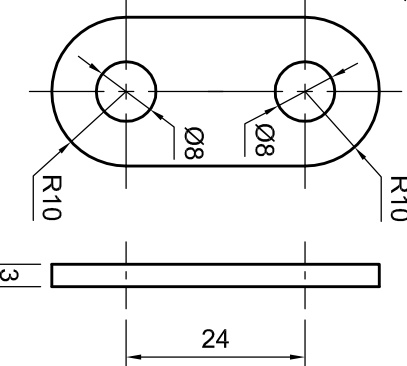
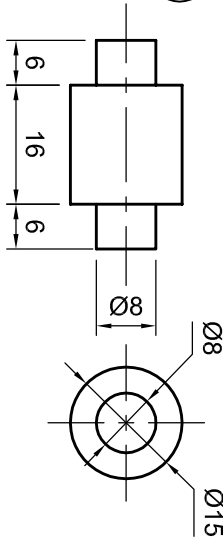
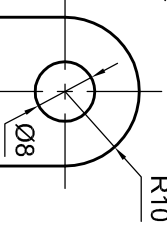
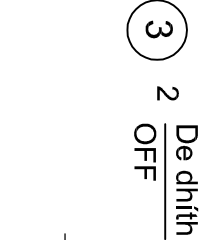
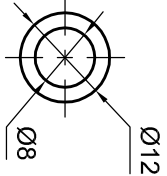
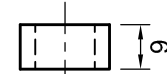
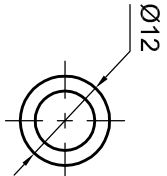
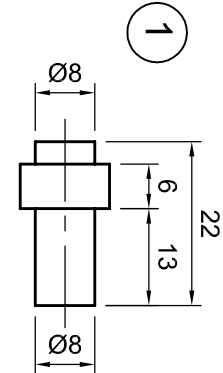
(ii) Tá tábhacht ag baint le cruinneas, le bailchríoch agus le hoibriú an triailphíosa.



Cuir an scrúdpháipéar seo agus an triailphíos isteach i gclúdach an iarthóra atá curtha ar fáil, agus tabhair an clúdach don Fheidhteoir ag deireadh an scrúdaithe. Put this examination paper and the test-piece into the candidate envelope supplied, and hand up the envelope to the Superintendent at the end of the examination.

Scriobh do Scrúduitheoir sa bhosca seo:

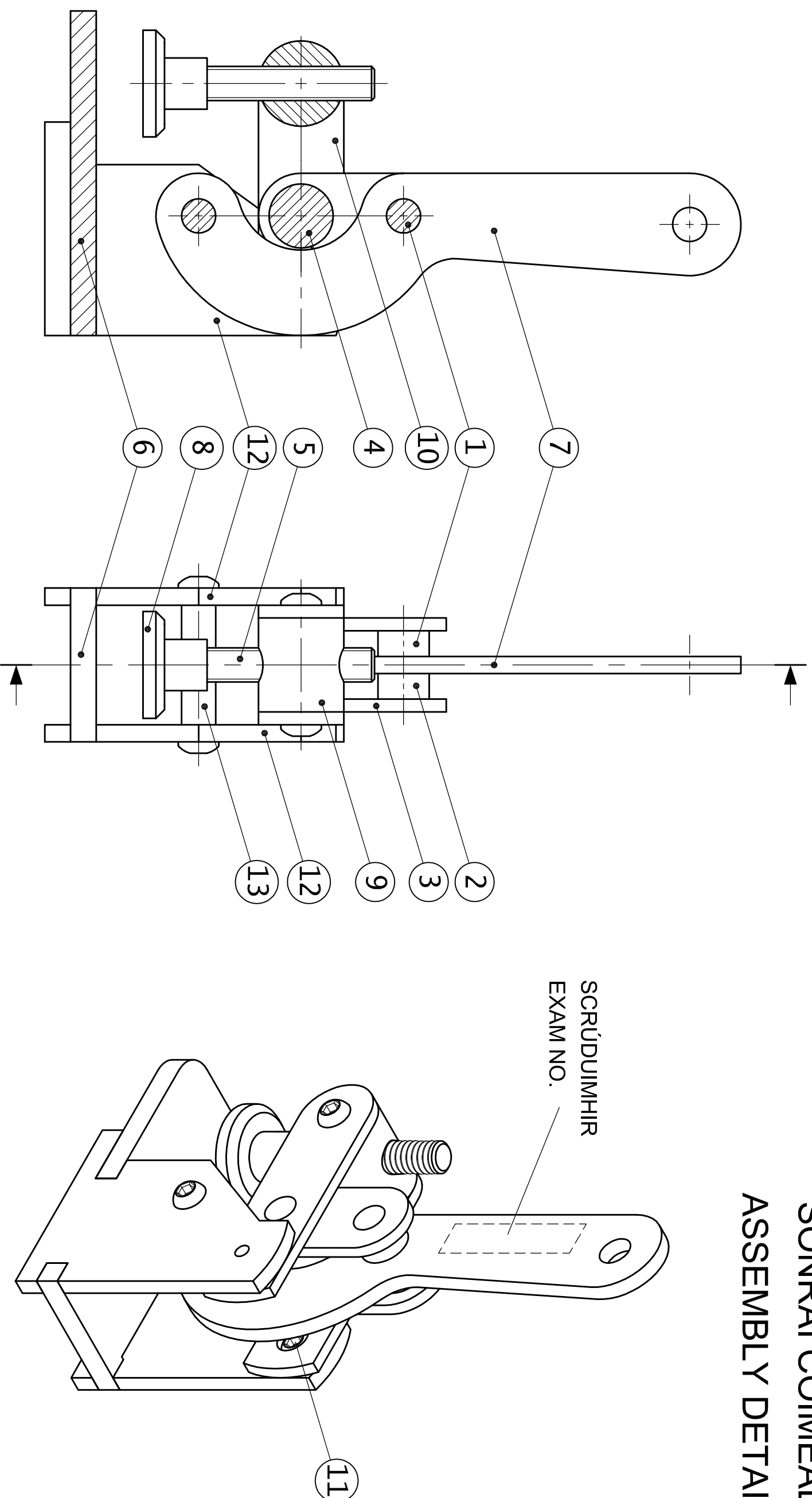
Write your Examination Number in this box:



THALL
OVER

SCRÚDÚ ARDTEISTIMÉIREACHTA - INNEALTÓIREACHT PRAITICIÚIL
LEAVING CERTIFICATE - ENGINEERING PRACTICAL

SONRAÍ CÓIMEÁLA
ASSEMBLY DETAILS



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Leaving Certificate Examination, 2022

Engineering - Practical (150 marks)

Morning: 10:00 to 1:00 - Afternoon: 2:00 to 5:00

Please Read Carefully

Instructions

- (a) The Examination Number must be clearly stamped or engraved, by the **teacher**, on the test-piece in the position indicated on the examination paper - 2022. M74A(L₂).
If the test-piece is not assembled, the Examination Number must be indicated on each separate part of the test-piece.
- (b) Candidates are not permitted to communicate with or assist one another.
- (c) Write your Examination Number in the box provided on the examination paper - 2022. M74A(L₁).
- (d) Put the examination paper - 2022. M74A(L₁) and the test-piece into the candidate envelope supplied, and hand up the envelope to the Superintendent at the end of the examination.

From the materials supplied, make the **Mechanism** shown on the drawings to the shape and dimensions specified.

PART	MATERIAL	PROCESS
6	Clear Polycarbonate	Mark out and shape.
7	Aluminium	Mark out, drill and shape.
10	Brass	Mark out, drill and shape.
12	Aluminium	Mark out, drill, tap and shape.

Note: (i) Parts 1, 2, 3, 4, 5, 8, 9, 11 and 13 have been made prior to examination day.
Using the screws supplied assemble the mechanism, as detailed on the assembly drawing.
(ii) **Accuracy, finish and function are important.**



Scrúdú na hArdteistiméireachta, 2022

Innealtóireacht - Praiticiúil
(150 marc)

Maidin: 10:00 go dtí 1:00 - Tráthnóna: 2:00 go dtí 5:00

Léigh na Treoracha seo go cúramach le do thoil

Treoracha

- (a) Ba chóir don **mhúinteoir** Scrúduimhir an Iarrthóra a stampáil nó a ghreanadh ar an triailphíosa san ionad a thaispeántar ar an scrúdpháipéar - 2022. M74A(L₂). Mura bhfuil an triailphíosa curtha le chéile, ní mór an Scrúduimhir a thaispeáint ar gach páirt ar leith den triailphíosa.
- (b) Níl cead ag iarrthóirí a bheith i gcumarsáid le chéile ná cúnamh a thabhairt dá chéile.
- (c) Scríobh do Scrúduimhir sa bhosca atá ann di ar an scrúdpháipéar - 2022. M74A(L₁).
- (d) Cuir an scrúdpháipéar - 2022. M74A(L₁) agus an triailphíosa isteach i gclúdach an iarrthóra atá curtha ar fáil, agus tabhair an clúdach don Fheitheoir ag deireadh an scrúdaithe.

As na hábhair a sholáthraítear, déan an **Mheicníocht** a thaispeántar sna líníochtaí sa chruth agus sna toisí a shonraítear.

PÁIRT	ÁBHAR	PRÓISEAS
6	Polacarbónáit thrédhearcach	A mharcáil amach agus a dheilbhiú.
7	Alúmanam	A mharcáil amach, a dhruileáil agus a dheilbhiú.
10	Prás	A mharcáil amach, a dhruileáil agus a dheilbhiú.
12	Alúmanam	A mharcáil amach, a dhruileáil, a tapa agus a dheilbhiú.

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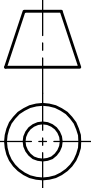
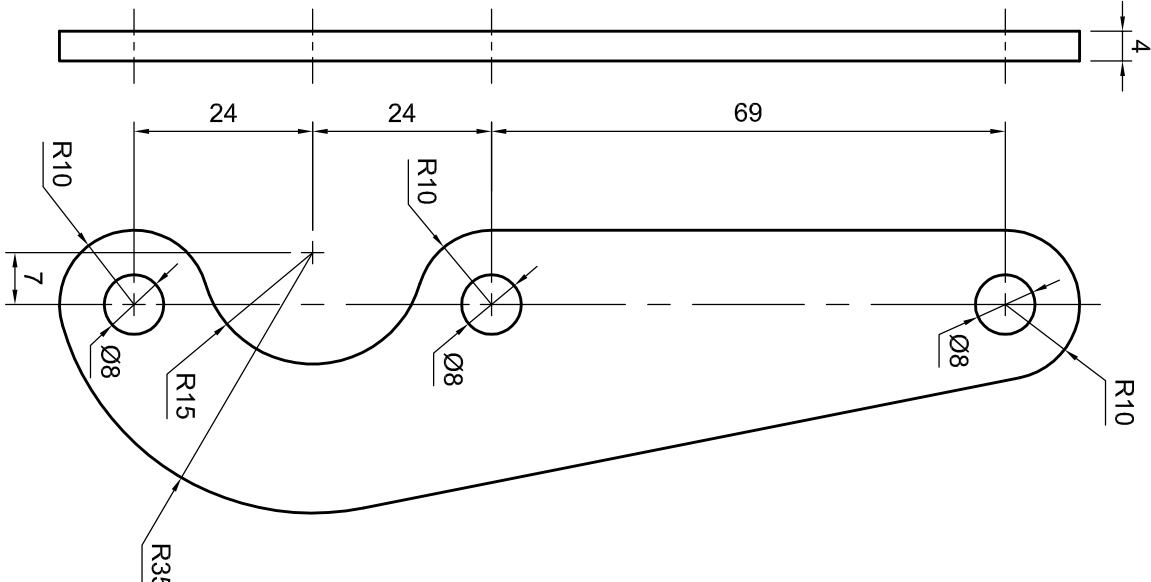
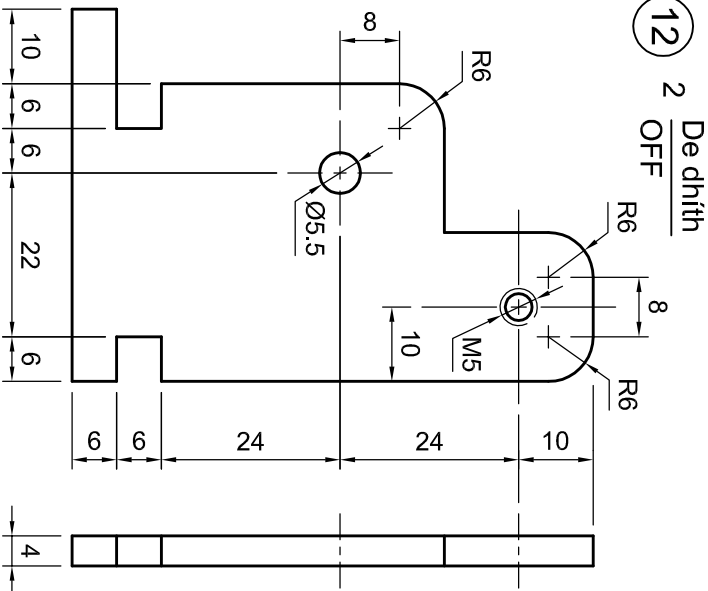
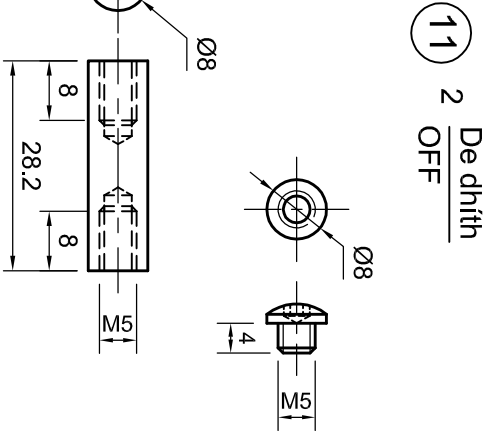
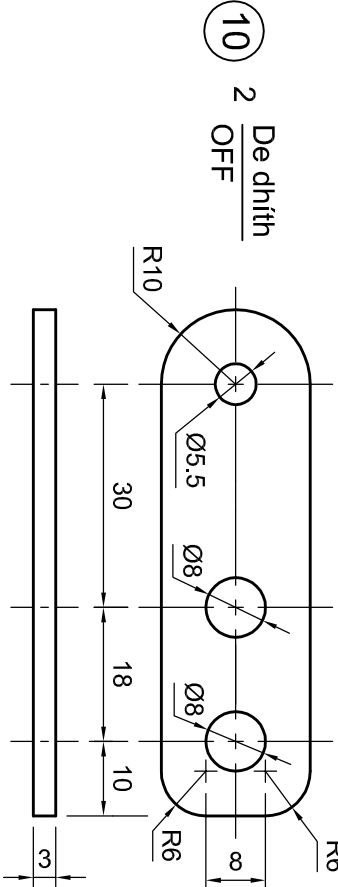
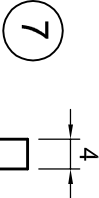
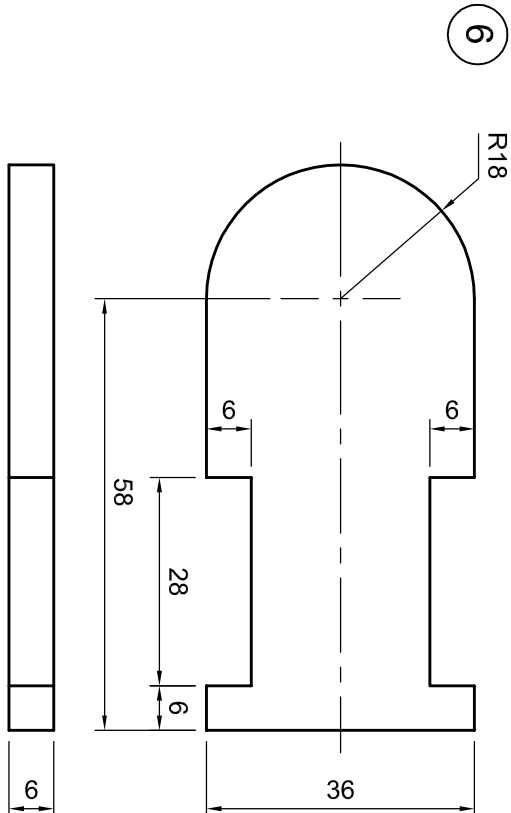
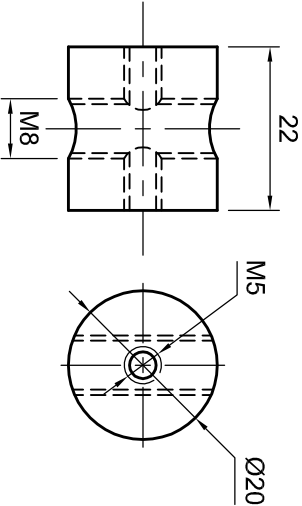
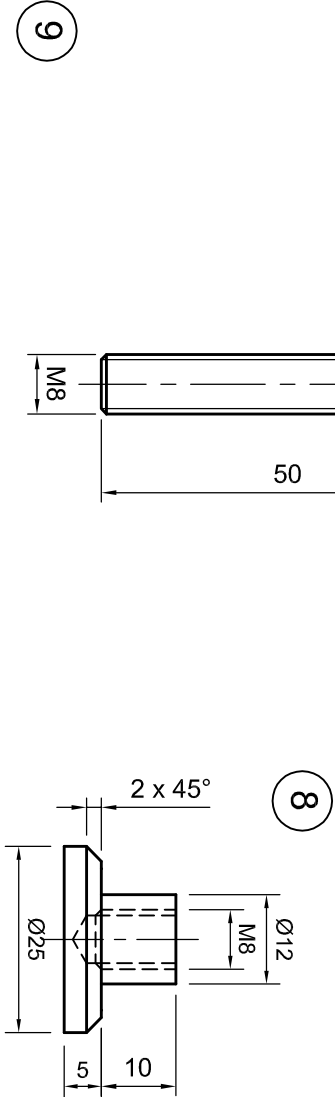
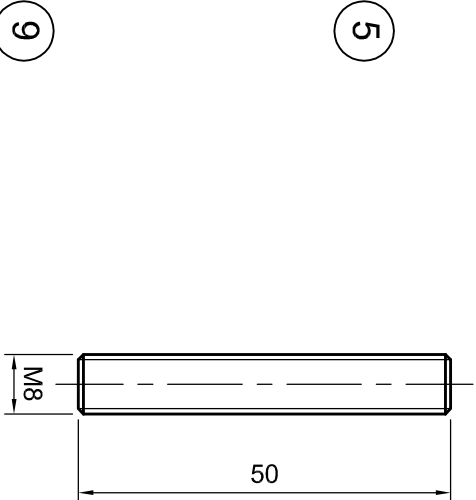
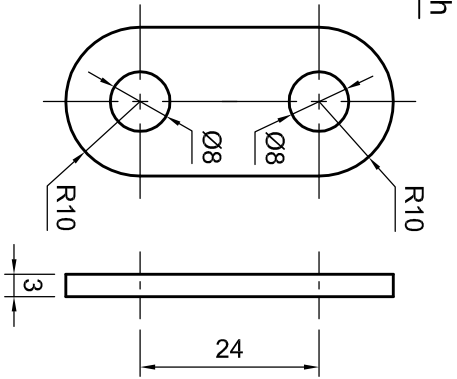
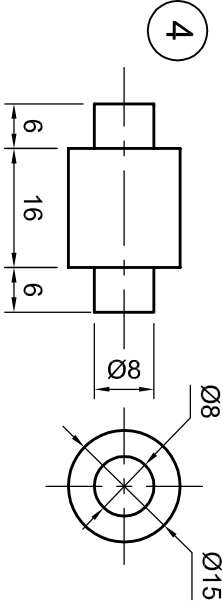
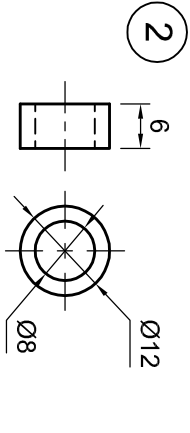
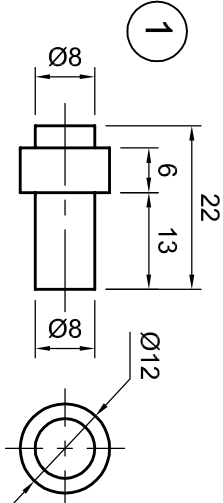


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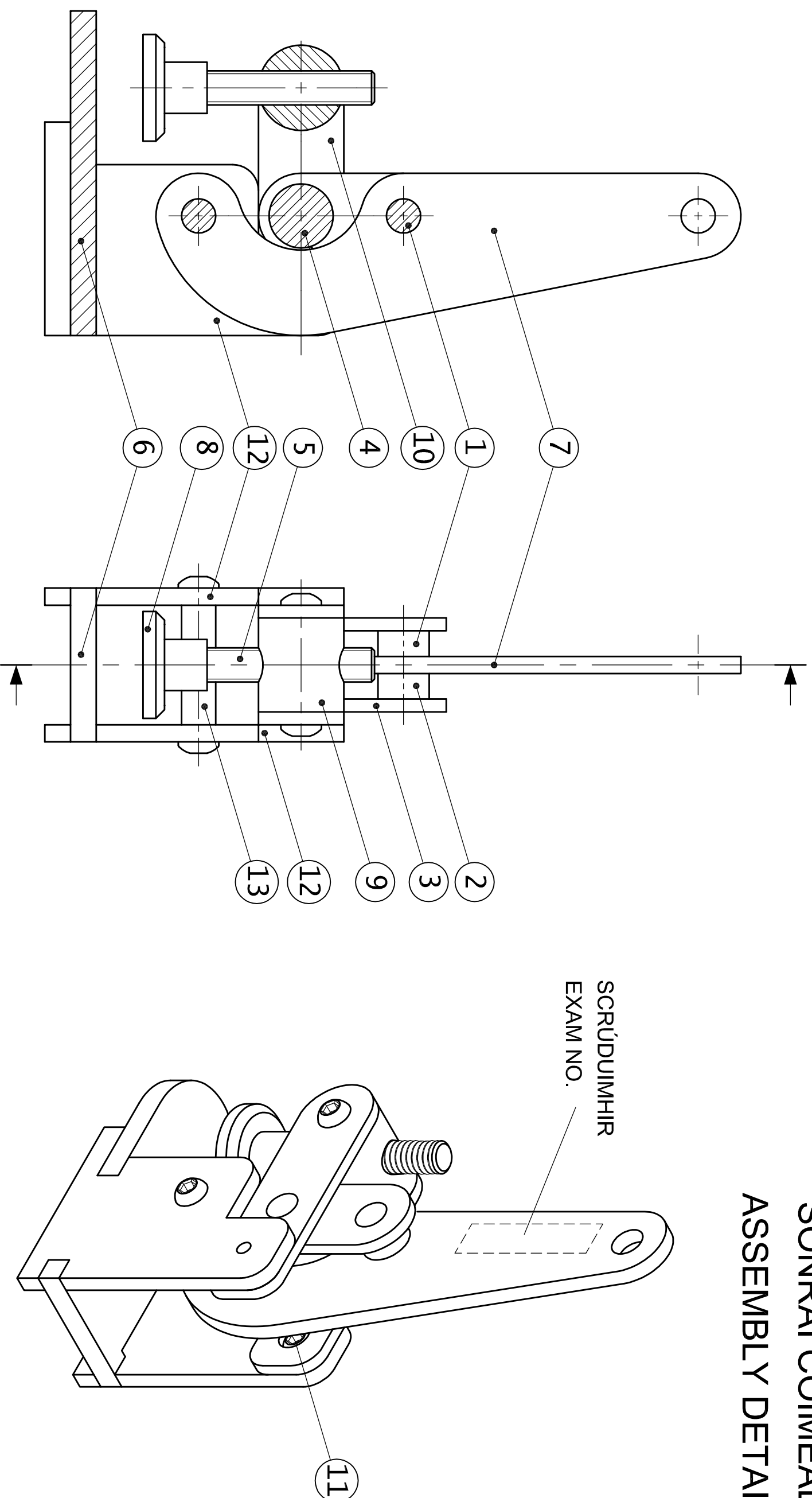
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