Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2019

ENGINEERING – MATERIALS AND TECHNOLOGY

(Higher level – 300 marks)

THURSDAY, 6th JUNE **MORNING, 9:30 – 12:30**

INSTRUCTIONS

1. Answer **Section A** and **Section B** of **Question 1** and **FOUR** other questions.

2. All answers must be written in ink on the answer book supplied.

3. Diagrams should be drawn in pencil.

4. Squared paper is supplied for graphs, as required.

5. Please label and number carefully each question attempted.

Question 1. **(100 marks)**

Section A – 50 marks

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

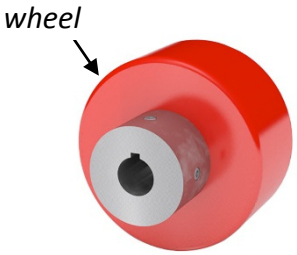
(a) Outline **two** reasons for the use of carbon composite materials in the manufacture of body panels for the prototype flying taxi, AeroMobil 5.0 VTOL.

(b) Describe, with the aid of a diagram, the process of flotation separation.

(c) Identify the main advantages of the use of pneumatic power in industry.

(d) Discuss the contribution that **any one** of the following has made to technology:
(i) Robert Boyle (ii) Kim Eric Drexler (iii) Theodore Maiman.

(e) The heavy-duty conveyor wheel shown is driven by a stepper motor. Describe with the aid of a diagram, **one** method of securely attaching this wheel to the stepper motor shaft.



(f) Outline **two** advantages for using nylon to make the wheel shown.

(g) Distinguish, with the aid of diagrams, between a *clearance fit* and an *interference fit*.

(h) Identify **three** possible quenching media used during the heat treatment of metal.

(i) Anodised tubular aluminium is used in the manufacture of the hiking stick shown. Outline **one** reason for anodising aluminium.

(j) The hiking stick is telescopic to cater for people of different heights. Explain, with aid of a diagram, how the hiking stick may be designed to accommodate a telescopic adjustment.

(k) Explain, with an example, the term *semi-conductor*.

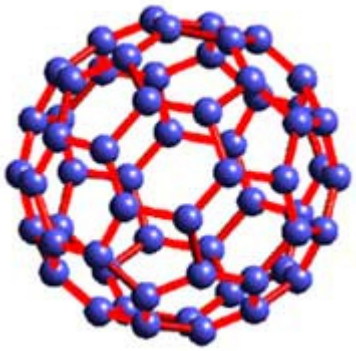
(l) List **three** details which are usually shown on a design drawing.

(m) Explain the significance of the colour-coding in the safety signs shown.

Section B – 50 marks

Answer **all** of the following:

(n) Nanotechnology is commonly described as an emerging technology. In 1985 British scientist, Harry Kroto, launched the spherical fullerene shown opposite, which is commonly known as a '*buckyball*'.



(i) Describe the term nanotechnology.

(ii) Explain the structure and properties of a *buckyball*.

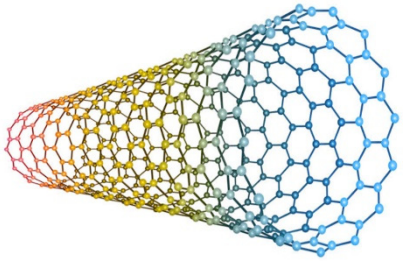
(o) Scanning probe technology is central to the development of nanomaterials. Outline, with the aid of a diagram(s), the operation of **one** of the following:

(i) Atomic Force Microscope (AFM).

(ii) Scanning Tunnelling Microscope (STM).

(p) Describe specific applications of nanotechnologies in **each** of the following:

- Diagnosis of medical conditions
- Delivery of drugs
- Prevention of superbugs.



(q) Graphene sheets and carbon nanotubes are central to the development of nanotechnologies.

(i) Describe the construction of carbon nanotubes.

(ii) Outline **three** mechanical properties of graphene sheets.

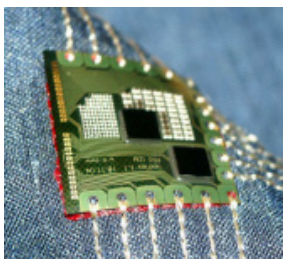
(r) Describe how nanotechnology could benefit **any two** of the following:

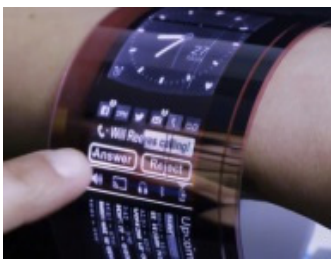
(i) Electronics.

(ii) Environmental protection.

(iii) Clothing.

(iv) Water purity.





Question 2. **(50 marks)**

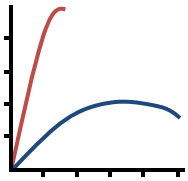
(a) The design and manufacture of the engine crankshaft in high performance sports cars must take into account both *metal fatigue* and *metal hardness*.

(i) Describe the terms *metal fatigue* and *metal hardness*.

(ii) Describe, with the aid of a diagram(s), a test for metal hardness.

(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	135	150	162	140
Metal A & B	**Strain (× 1000)**	0.50	1.00	1.50	2.00	3.00	4.00	6.00	8.00



(i) Using the graph paper supplied, plot the stress-strain diagram for **metal A** and the stress-strain diagram for **metal B** using the same graph axes, as shown opposite.

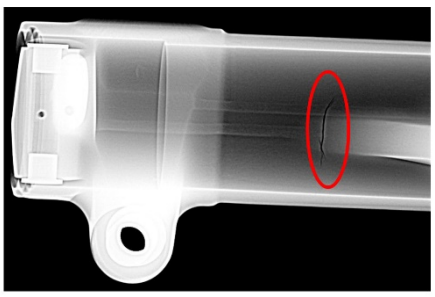
(ii) Describe, with the aid of a diagram, the type of fracture which will occur when **metal A** breaks and the type of fracture which will occur when **metal B** breaks.

(iii) Give **one** example of a metal that is consistent with the graph of **metal A** and **one** example of a metal that is consistent with the graph of **metal B**.

(c) Non-destructive testing (NDT) is critical in the design and maintenance of a wide range of components.

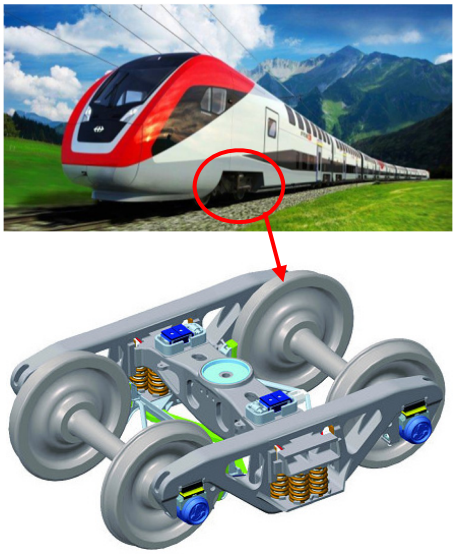
(i) Outline **one** application for **each** of the following methods of NDT:

- Visual inspection
- Dye penetrant testing
- Magnetic particle testing
- Eddy current testing.



(ii) Describe, with the aid of a diagram(s), **one** suitable radiography (x-ray) NDT method.

Question 3. **(50 marks)**

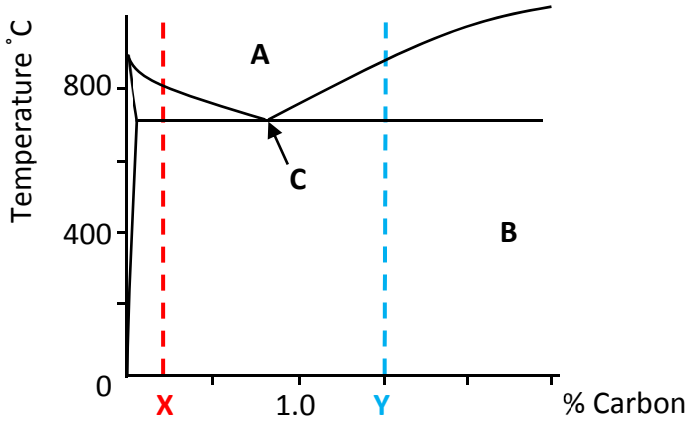


(a) Railway carriage wheels are subject to heat treatments during manufacture such as hardening of the outer wheel surface and annealing of the centre hub.

(i) Outline the purpose of annealing the centre hub.

(ii) Describe a suitable heat treatment procedure for the outer surface of the carriage wheel.

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



(i) Name the regions **A** and **B**.

(ii) Compare the main properties of the metal with 0.2% carbon at **X** **and** the metal with 1.5% carbon at **Y**.

(iii) Describe the point **C** in terms of phase change, temperature and composition.

(c) Compare flame hardening and induction hardening with reference to the following:

- Equipment
- Procedures
- Quenching.

Question 4. **(50 marks)**

(a) Select **any two** from **(i)**, **(ii)** or **(iii)** below and explain the difference between the terms in **each**:

(i) Cooling curve for an alloy and a cooling curve for a pure metal.

(ii) Amorphous materials and crystalline materials.

(iii) Eutectic point and eutectoid point.

(b) The table shows the solidification temperatures for various alloys of Cadmium and Bismuth.

% of Cadmium in alloy	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
Start of solidification (°C)	268	237	205	175	140	190	235	265	290	310	321
End of solidification (°C)	140	140	140	140	140	140	140	140	140	140	140

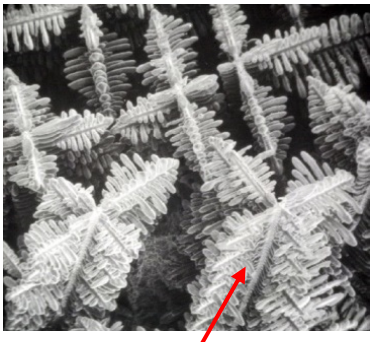
Using the graph paper supplied:

(i) Draw the equilibrium diagram using the given data.

(ii) Label and describe the key features of the diagram.

(iii) Explain the term *eutectic alloy*.

(c) The microscopic image opposite shows the formation of dendrites in the process of dendritic growth as a metal solidifies from the liquid stage to the solid stage.



(i) Describe, with the aid of diagrams, the stages of dendritic growth.

(ii) Name and describe **two** crystal point defects which may occur during the metal solidification process.

Question 5. **(50 marks)**

(a) The spiral playground slide shown is partially manufactured from stainless steel, and is to be welded to the vertical stainless steel pole using tungsten inert gas (TIG) welding.

(i) Describe, with the aid of a diagram, the process of tungsten inert gas (TIG) welding.

(ii) State **two** reasons for the use of tungsten inert gas (TIG) welding for securing the stainless steel slide.

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

(i) Explain the function of a rectifier in arc welding.

(ii) Describe how an acetylene cylinder is filled under low pressure.

(iii) Describe, with the aid of a diagram, the process of friction welding.

(iv) Explain how the flux coating prevents oxidation in manual metal arc welding.

(v) Outline **two** safety hazards associated with metal inert gas (MIG) welding in a school workshop.

(c) Compare, with the aid of suitable diagrams, resistance spot welding **and** resistance seam welding, using the following headings:

- Electrode shape
- Welding procedure
- Applications of each weld type
- Safety considerations.

OR

(c) The exoskeleton suit shown opposite is a wearable robotic suit which provides enhanced individual mobility for humans.

(i) Discuss the impact of the robotic suit in the following areas:

- Assisting a person with a disability
- Rehabilitation due to injury.

(ii) Outline **two** other applications of robotic control in medicine.

Question 6. **(50 marks)**

(a) Irish sailors and rowers have experienced considerable success in recent years culminating in Olympic and World Championship glory for the O'Donovan brothers and for Sanita Puspure.

Racing boat components, such as the oarlocks shown, have been highly engineered to improve racing performance.

(i) State **two** key thermoplastic material properties to be considered for the manufacture of the oarlock body shown.

(ii) Name and describe a suitable manufacturing process for the mass production of the oarlock body shown.

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

(i) Outline the basic principles of copolymerisation.

(ii) Describe the difference between *elastic memory* and *elasticity* in thermoplastics.

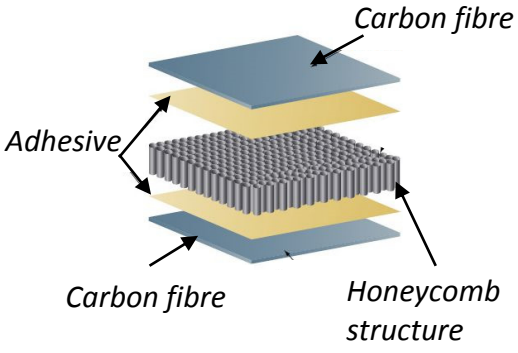
(iii) Discuss the use of lubricants in polymer manufacturing processes.

(iv) Outline the negative effects on the environment of the continuous use of polymer materials.

(c) Racing boats are usually made from laminated carbon fibre materials with a honeycomb structure.

(i) Describe the terms *laminated* and *carbon fibre*.

(ii) Outline the importance of the honeycomb structure in the manufacture of racing boats.



Question 7. **(50 marks)**

(a) Cutting fluids are an essential part of machine cutting operations.

(i) Explain how the use of cutting fluids impact on:

- Material surface finish
- Cutting tool life.

(ii) Describe how cutting fluids are maintained to prevent rancidity.

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

(i) Explain, with diagrams, the difference between *up-cut* and *down-cut* milling.

(ii) Outline **two** safety features integrated into a bench grinder.

(iii) Describe the main differences between a reamer and a drill bit.

(iv) Explain, with a diagram, the difference between a *rake angle* and a *clearance angle*.

(v) Describe **one** method of securing a machine vice safely to a drilling table.

(c) Tungsten carbide is the material of choice in the manufacture of mining tips, drill bits and other cutting tools.

(i) Explain how tungsten carbide insert tips are manufactured.

(ii) Outline **two** advantages of the use of tungsten carbide insert tips.

OR

(c) Computer Numerical Control (CNC) technology is to the forefront of precision engineering manufacture.

(i) Explain the following aspects of CNC technology:

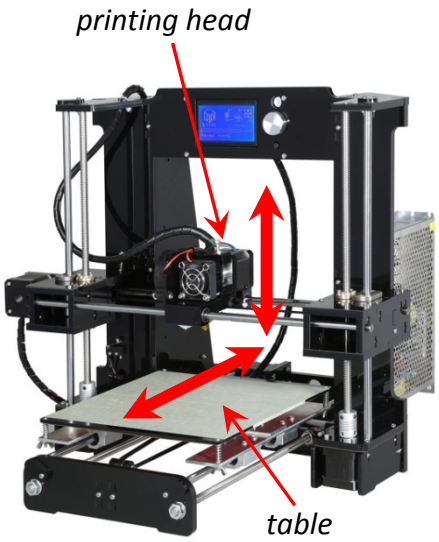
- Impact on productivity
- Reliability.

(ii) Describe the following CNC machining operations:

- Automatic tool change
- Test run.

Question 8. **(50 marks)**

(a) In the 3D printer shown opposite, a leadscrew mechanism is used to move the printing head vertically.



(i) Describe, with the aid of a diagram, how the leadscrew mechanism raises and lowers the height of the printing head when in use.

(ii) Describe, with the aid of a diagram, an alternative mechanism which will allow the table of the printer to move forwards and backwards.

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

(i) Explain how a worm and worm gear transmits motion through 90°.

(ii) Outline **one** energy conversion which occurs in a car battery.

(iii) State **one** advantage of a toothed belt drive over a chain drive.

(iv) Describe, with the aid of a diagram, the operation of an idler gear.

(v) Explain how a lifting winch may operate using a ratchet and pawl mechanism.

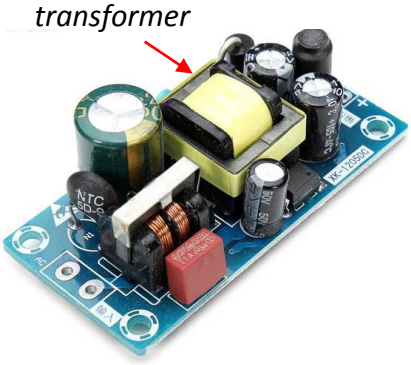
(c) The crop spraying unit shown opposite is suitable for attaching to a quad bike and has retractable boom spraying arms.

(i) Describe, with the aid of a diagram, a suitable retractable mechanism for the spray boom.

(ii) Describe **one** advantage and **one** disadvantage of retractable boom spraying arms.

OR

(c) A control circuit for electronic appliances and devices is shown. This circuit generally delivers a 6-12V power supply.



(i) Describe the function of the transformer in the circuit shown.

(ii) Identify **one** other component in the circuit shown.

Leaving Certificate – Higher Level

Engineering – *Materials and Technology*

Thursday 6th June
Morning 9:30 – 12:30

Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate Examination, 2019

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 - 2019. M74A(L_2).
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 - 2019. M74A(L_1).

(d) Put the examination paper - 2019. M74A(L_1) 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 **Lock Mechanism** shown on the drawings to the shape and dimensions specified.

PART	MATERIAL	PROCESS
3	Clear Polycarbonate	Mark out, drill, tap and shape.
5	Brass	Mark out, drill and shape.
6	Aluminium	Mark out, drill and shape.

Note: **(i)** Parts 4, 7, 8 and 9 have been made prior to examination day. Parts 1 and 2 has been part-prepared. Using the screws supplied assemble the mechanism, as detailed on the assembly drawing.

(ii) Accuracy, finish and function are important.

Coimisiún na Scrúduithe Stáit
State Examinations Commission

Scrúdú na hArdteistiméireachta, 2019

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 - 2019. M74A(L_2). 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 - 2019. M74A(L_1).

(d) Cuir an scrúdpháipéar - 2019. M74A(L_1) 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 Ghlais** a thaispeántar sna líníochtaí sa chruth agus sna toisí a shonraítear.

PÁIRT	ÁBHAR	PRÓISEAS
3	Polacarbónáit thrédhearcach	A mharcáil amach, a dhruileáil, a tapa agus a dheilbhiú.
5	Prás	A mharcáil amach, a dhruileáil agus a dheilbhiú.
6	Alúmanam	A mharcáil amach, a dhruileáil agus a dheilbhiú.

Nóta: **(i)** Rinneadh na páirteanna 4, 7, 8 agus 9 roimh lá an scrúdaithe. Tá páirt 1 agus 2 páirtdéanta. Agus tú ag baint úsáide as na scriúnna a sholáthraítear, cóimeáil an mheicníocht faoi mar atá sa líníocht chóimeála.

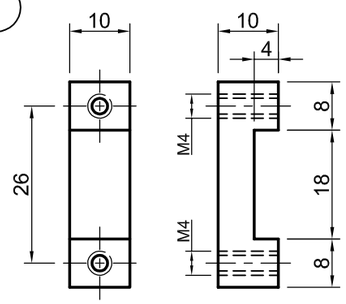
(ii) Tá tábhacht ag baint le cruinneas, le bailchríoch agus le hoibriú an triailphíosa.

Lá 1
Day 1

SCRÚDÚ ARDTEISTIMÉIREACHTA - INNEALTÓIREACHT PRAITICIÚIL
LEAVING CERTIFICATE - ENGINEERING PRACTICAL

2019. M74A(L 1)

1



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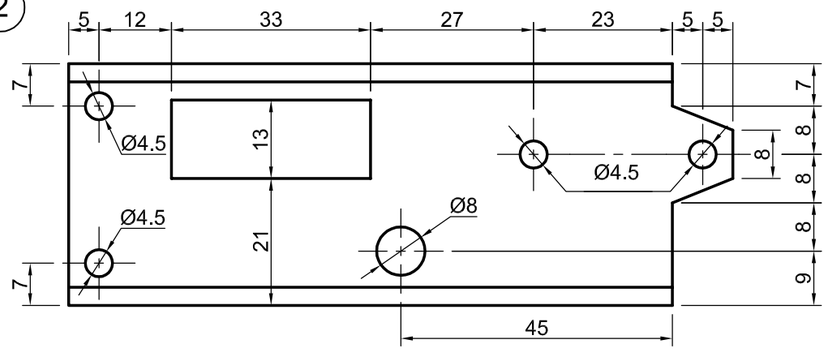

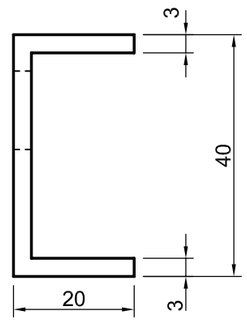

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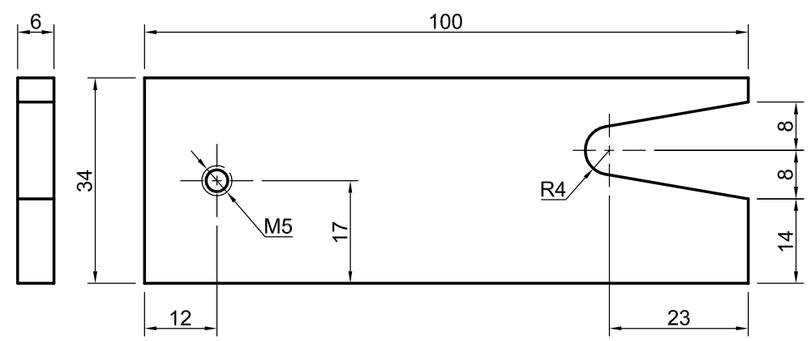

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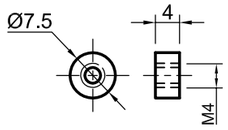

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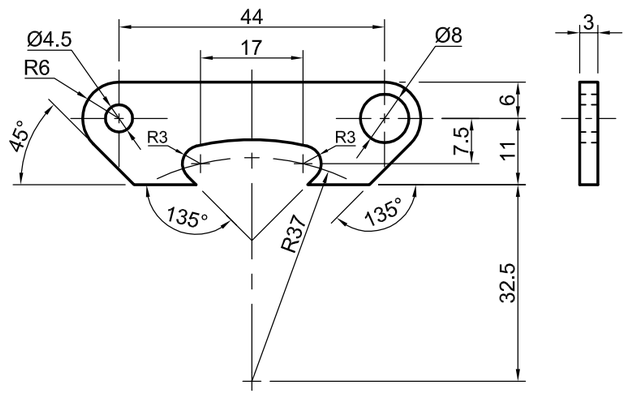

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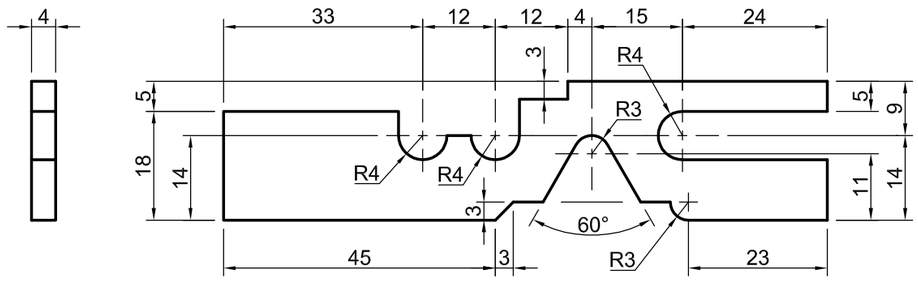
Put this examination paper and the test-piece into the candidate envelope supplied, and hand up the envelope to the Superintendent at the end of the examination.

6



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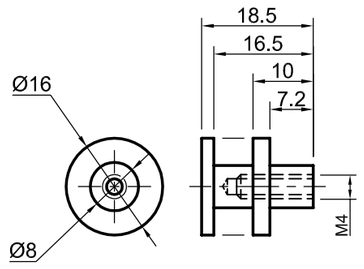
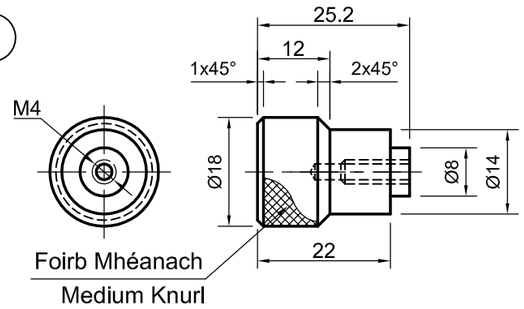


Scríobh do Scrúduimhir sa bhosca seo:
Write your Examination Number in this box:

8



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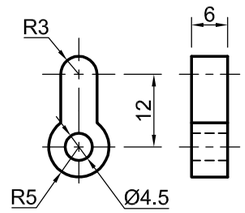
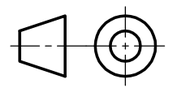


Nóta: Ba chóir go rothódh Páirteanna 7 agus 8 go saorálach i bpoll Ø8 mm

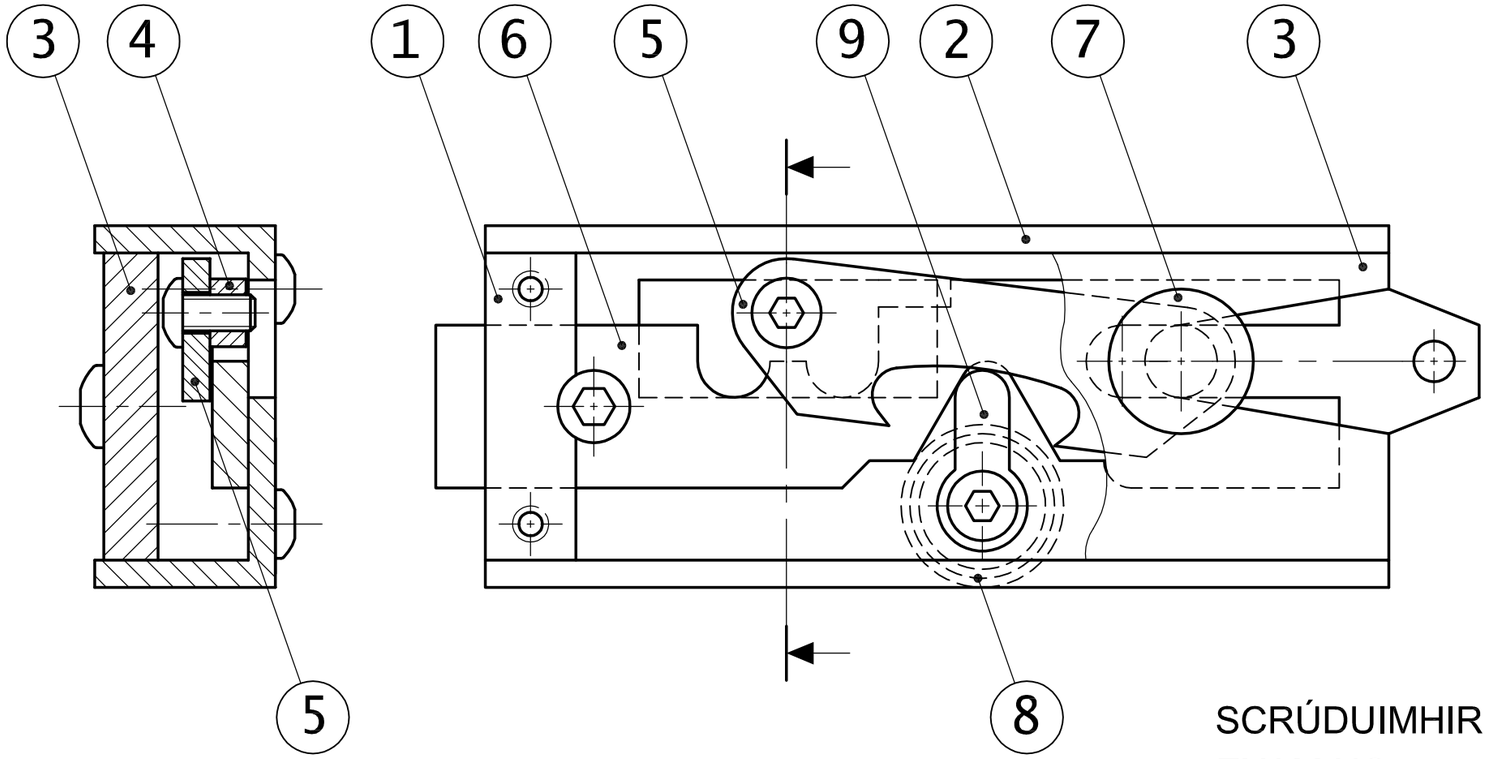
Note: Parts 7 and 8 should rotate freely in a Ø8 mm hole



THALL OVER

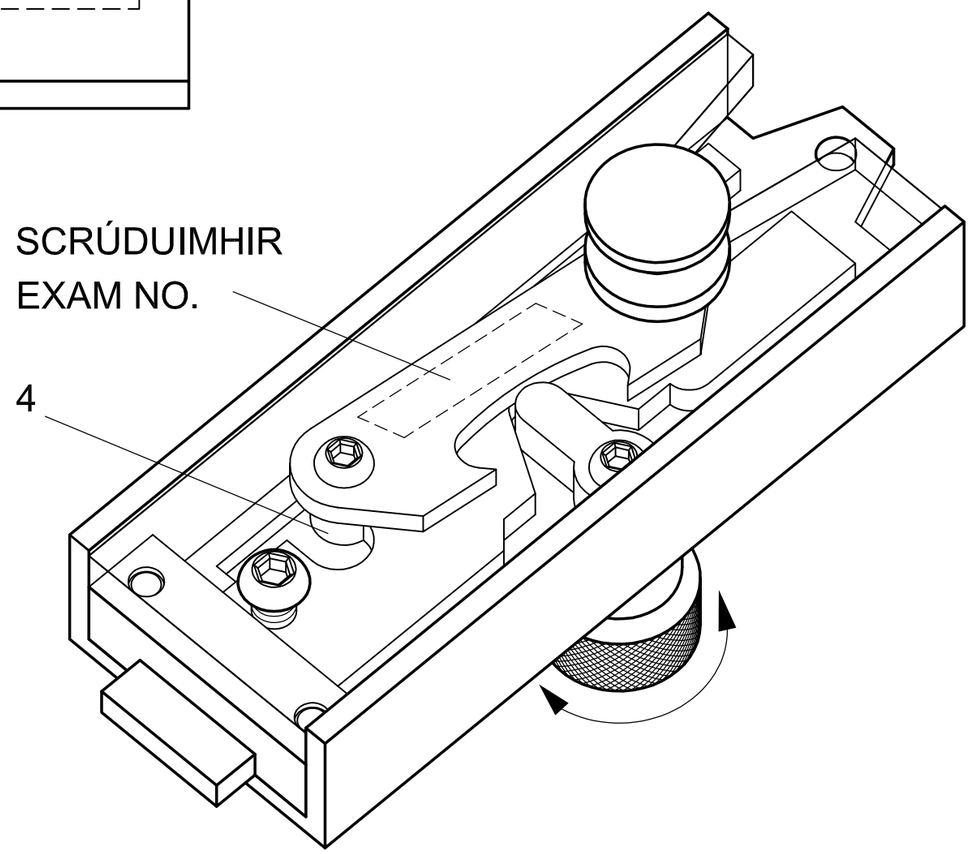
Coimisiún na Scrúduithe Stáit
State Examinations Commission

SCRÚDÚ ARDTEISTIMÉIREACHTA - INNEALTÓIREACHT PRAITICIÚIL
LEAVING CERTIFICATE - ENGINEERING PRACTICAL



SONRAÍ CÓIMEÁLA

ASSEMBLY DETAILS



Cuir an scrúdpháipéar seo agus an triailphíosa isteach i gclúdach an iarrthóra atá curtha ar fáil, agus tabhair an clúdach don Fheitheoir ag deireadh an scrúdaithe.

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Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate Examination, 2019

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 - 2019. M74A(L_2).
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 - 2019. M74A(L_1).

(d) Put the examination paper - 2019. M74A(L_1) 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 **Lock Mechanism** shown on the drawings to the shape and dimensions specified.

PART	MATERIAL	PROCESS
3	Clear Polycarbonate	Mark out, drill, tap and shape.
5	Brass	Mark out, drill and shape.
6	Aluminium	Mark out, drill and shape.

Note: **(i)** Parts 4, 7, 8 and 9 have been made prior to examination day. Parts 1 and 2 has been part-prepared. Using the screws supplied assemble the mechanism, as detailed on the assembly drawing.

(ii) Accuracy, finish and function are important.

Coimisiún na Scrúduithe Stáit
State Examinations Commission

Scrúdú na hArdteistiméireachta, 2019

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 - 2019. M74A(L_2). 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 - 2019. M74A(L_1).

(d) Cuir an scrúdpháipéar - 2019. M74A(L_1) 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 Ghlais** a thaispeántar sna líníochtaí sa chruth agus sna toisí a shonraítear.

PÁIRT	ÁBHAR	PRÓISEAS
3	Polacarbónáit thrédhearcach	A mharcáil amach, a dhruileáil, a tapa agus a dheilbhiú.
5	Prás	A mharcáil amach, a dhruileáil agus a dheilbhiú.
6	Alúmanam	A mharcáil amach, a dhruileáil agus a dheilbhiú.

Nóta: **(i)** Rinneadh na páirteanna 4, 7, 8 agus 9 roimh lá an scrúdaithe. Tá páirt 1 agus 2 páirtdéanta. Agus tú ag baint úsáide as na scriúnna a sholáthraítear, cóimeáil an mheicníocht faoi mar atá sa líníocht chóimeála.

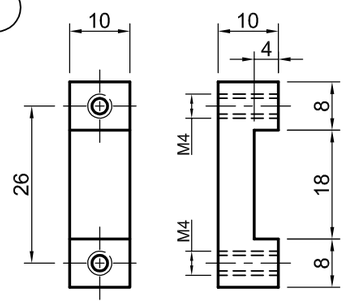
(ii) Tá tábhacht ag baint le cruinneas, le bailchríoch agus le hoibriú an triailphíosa.

Lá 2
Day 2

SCRÚDÚ ARDTEISTIMÉIREACHTA - INNEALTÓIREACHT PRAITICIÚIL
LEAVING CERTIFICATE - ENGINEERING PRACTICAL

2019. M74A(L 1)

1



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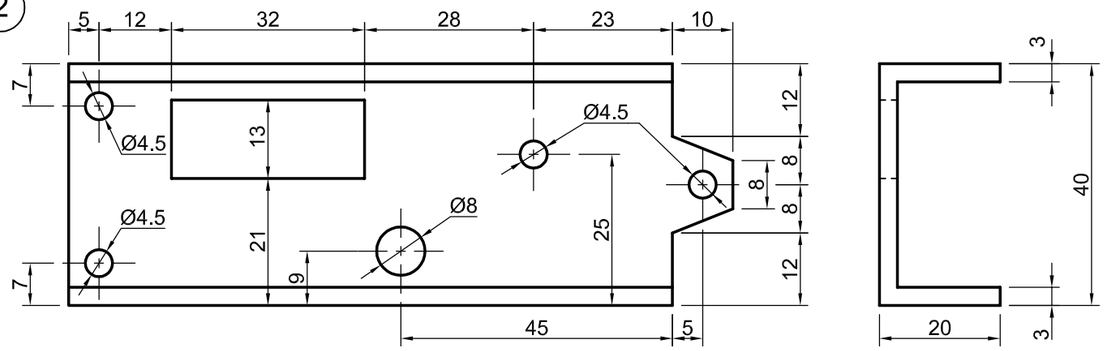

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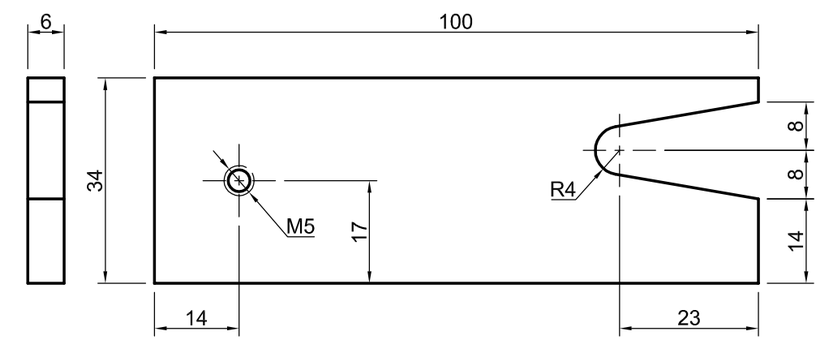

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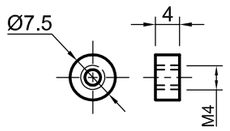

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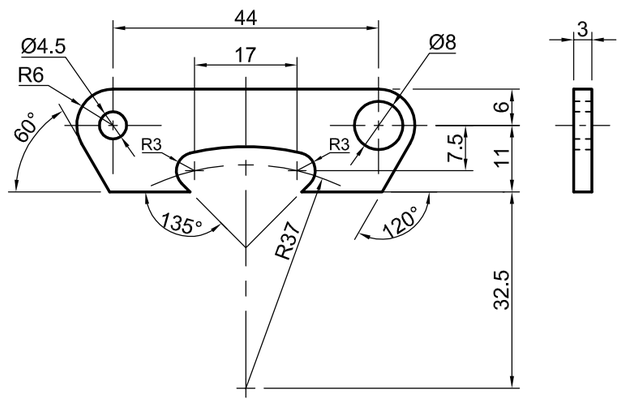

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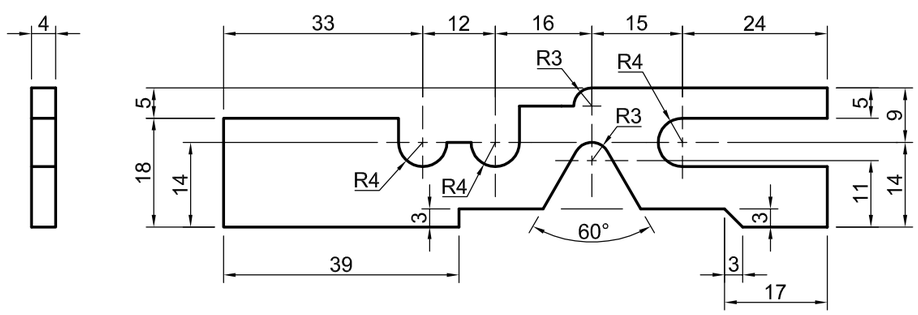

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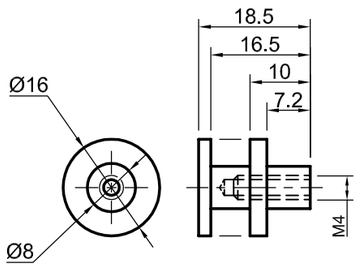
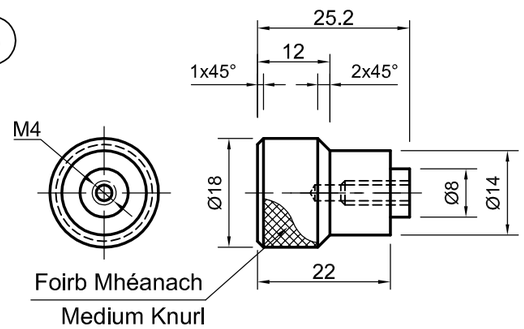


Scríobh do Scrúduimhir sa bhosca seo:
Write your Examination Number in this box:

8



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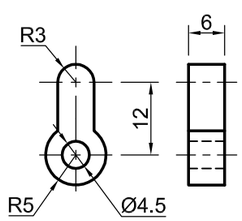
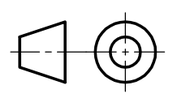


Nóta: Ba chóir go rothódh Páirteanna 7 agus 8 go saorálach i bpoll Ø8 mm

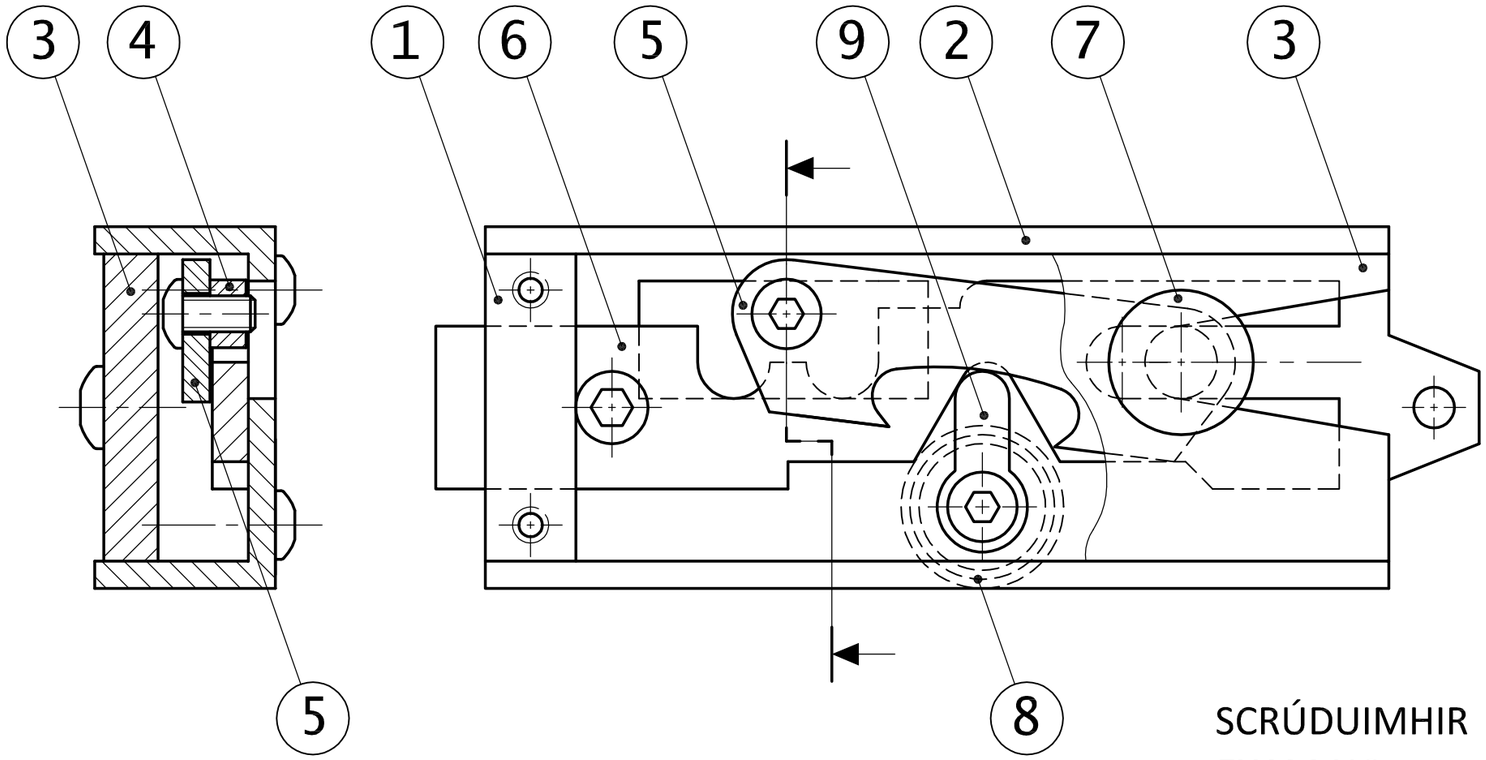
Note: Parts 7 and 8 should rotate freely in a Ø8 mm hole



THALL OVER

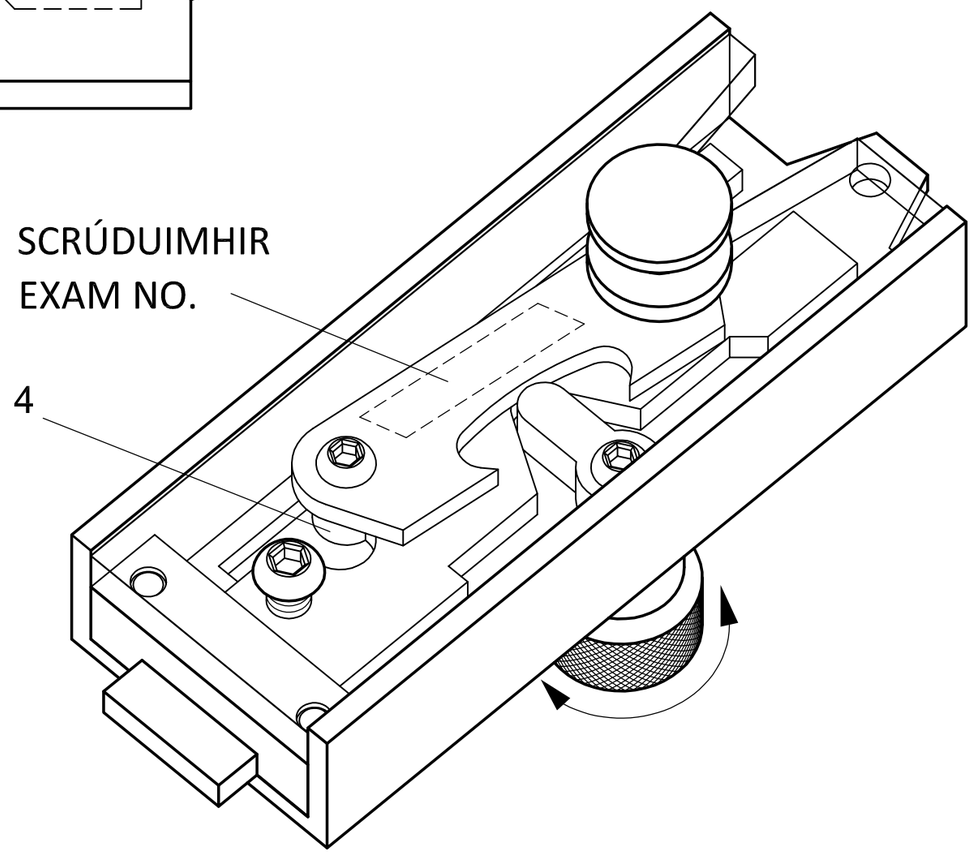
Coimisiún na Scrúduithe Stáit
State Examinations Commission

SCRÚDÚ ARDTEISTIMÉIREACHTA - INNEALTÓIREACHT PRAITICIÚIL
LEAVING CERTIFICATE - ENGINEERING PRACTICAL



SONRAÍ CÓIMEÁLA

ASSEMBLY DETAILS



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Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate Examination, 2019

Engineering - Practical

(150 marks)

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Coimisiún na Scrúduithe Stáit
State Examinations Commission

Scrúdú na hArdteistiméireachta, 2019

Innealtóireacht - Praiticiúil

(150 marc)

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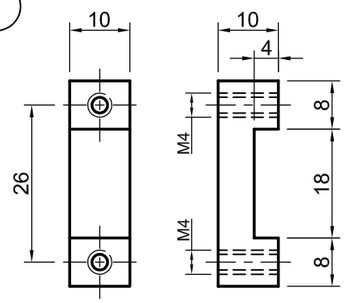
(ii) Tá tábhacht ag baint le cruinneas, le bailchríoch agus le hoibriú an triailphíosa.

Lá 3
Day 3

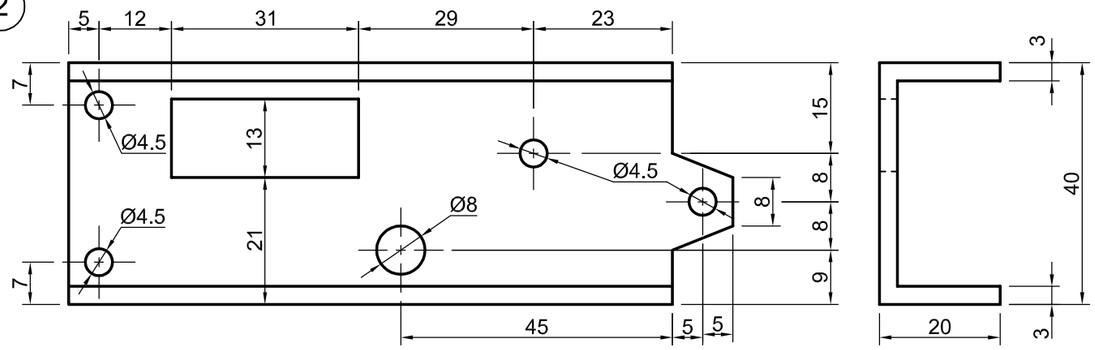
SCRÚDÚ ARDTEISTIMÉIREACHTA - INNEALTÓIREACHT PRAITICIÚIL
LEAVING CERTIFICATE - ENGINEERING PRACTICAL

2019. M74A(L 1)

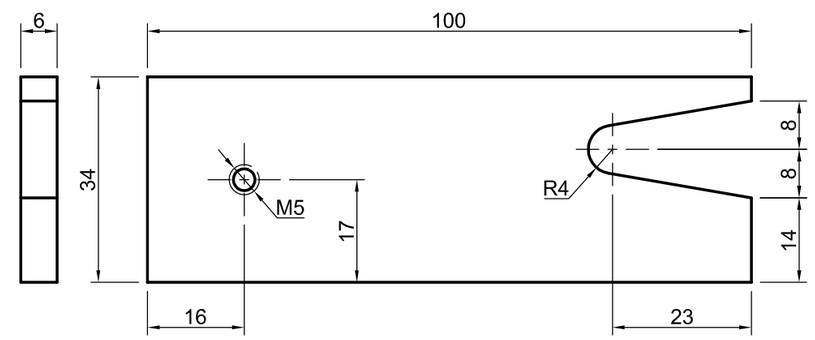
1



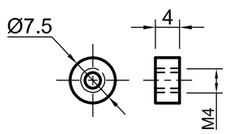
2



3



4



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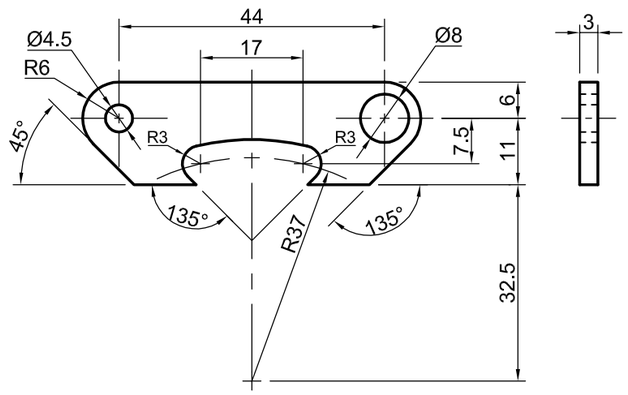

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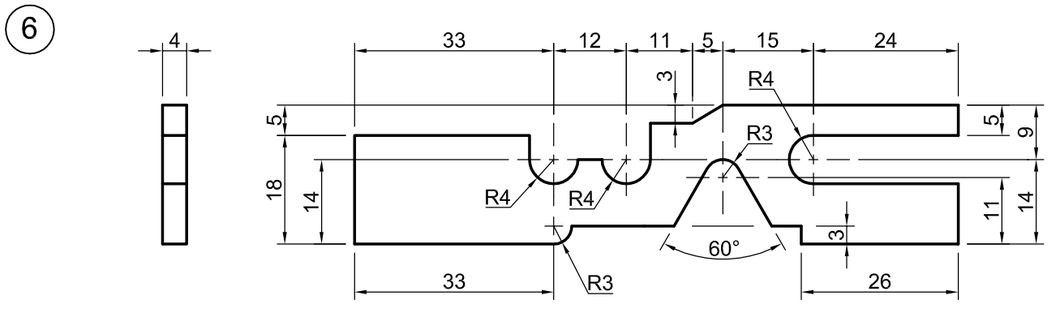
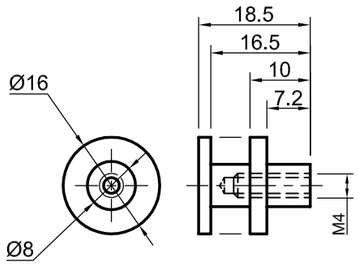


7



Scríobh do Scrúduimhir sa bhosca seo:
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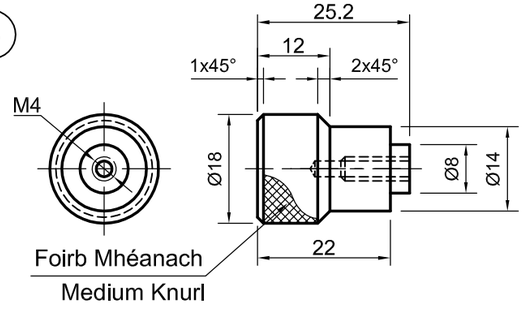
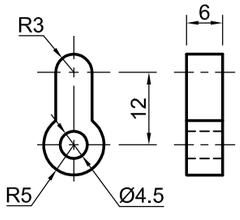
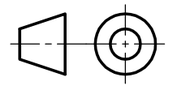


9



Nóta: Ba chóir go rothódh Páirteanna 7 agus 8 go saorálach i bpoll Ø8 mm

Note: Parts 7 and 8 should rotate freely in a Ø8 mm hole



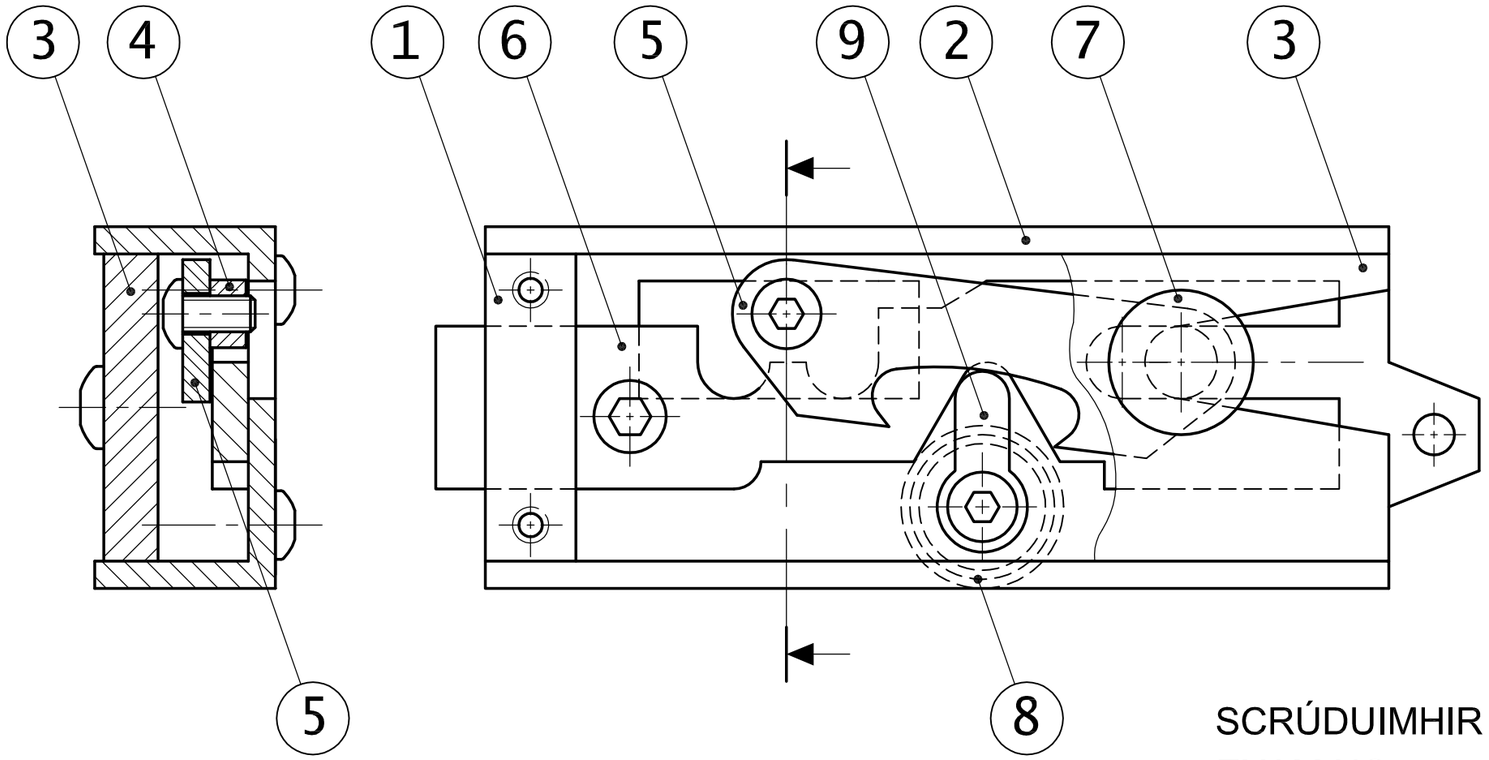
THALL OVER

Lá 3
Day 3

Coimisiún na Scrúduithe Stáit
State Examinations Commission

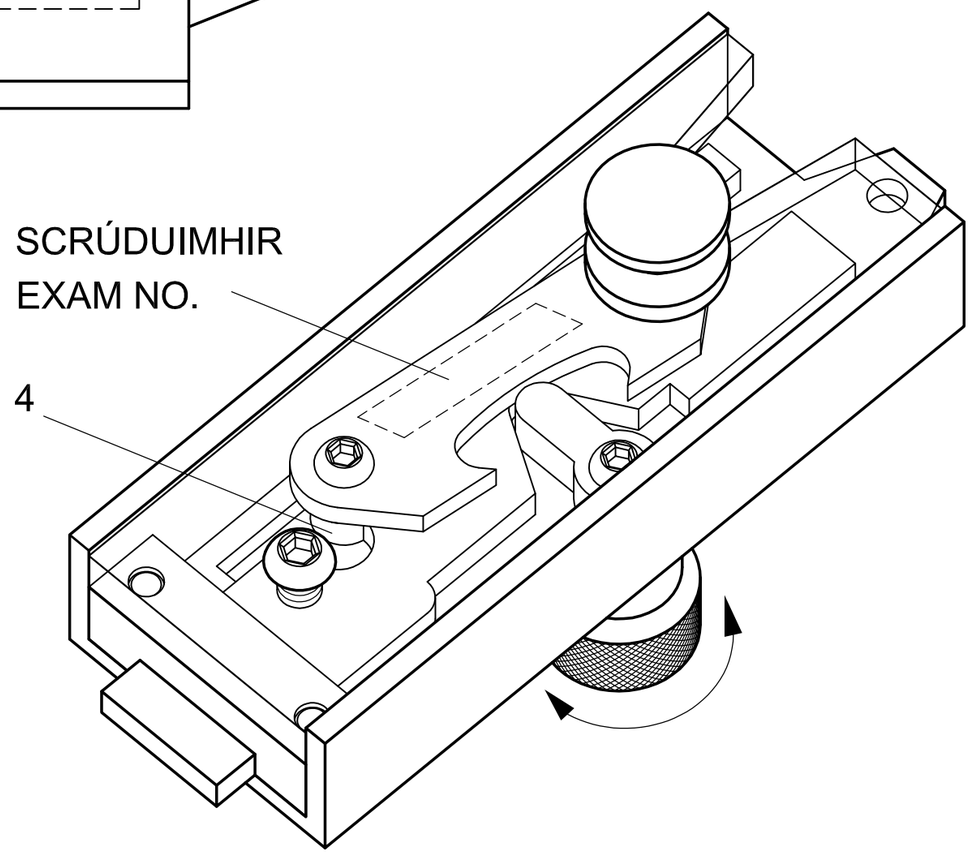
2019. M74A(L_2)

SCRÚDÚ ARDTEISTIMÉIREACHTA - INNEALTÓIREACHT PRAITICIÚIL
LEAVING CERTIFICATE - ENGINEERING PRACTICAL



SONRAÍ CÓIMEÁLA

ASSEMBLY DETAILS



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