MECHANICAL DESIGN 3
7145

CAMEROON GENERAL CERTIFICATE OF EDUCATION BOARD

Technical and Vocational Education Examination

JUNE XXXX   **ADVANCED LEVEL**

Specialty Name (Specialty Code)	MAME, HBMA, MWIP, AM-LV, AM-HD
Subject Title	**MECHANICAL DESIGN**
Paper No.	**3**
Subject Code No.	**7145**

Three hours

INSTRUCTIONS TO CANDIDATES

You are reminded of the necessity for good English and orderly presentation in your answers.

You are advised to read carefully through the question paper, before you begin your answers.

RECOMMENDATIONS

- *No document is authorized;*
- *This paper comprises two sections:*
  - ❖ **Section A: ONLY FOR**
    - *Automobile Construction and Maintenance:* **AM – LV (MA – VT);**
    - *Automobile Construction and Maintenance:* **AM – HD (MA – PL);**
    - *Manufacturing Mechanics:* **MAME (F1);**
    - *Hospital and Biomedical maintenance:* **HBMA (MHB)**
  - ❖ **Section B: FOR ONLY:**
    - *Metal Works and Industrial Piping:* **MWIP (MFCM)**

_____ *Turn Over*

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SECTION A

Section A: ONLY FOR
- *Automobile Construction and Maintenance : AM – LV (MA - VT);*
- *Automobile Construction and Maintenance : AM – HD (MA - PL);*
- *Manufacturing Mechanics: MAME (F1).*
- *Hospital and Biomedical maintenance: HBMA (MHB)*

- *The work to be done comprises two independent parts:*
   - ***- PART I: Technological study*** *(20 MARKS) and*
   - ***- PART II: Graphical study*** *(30MARKS)*
- *Make sure you have been distributed 24 sheets numbered from 1 to 13 the answer sheets from 8 to 13 are to be handed to the examiner at the end of the paper ,filled or not.*
- *The candidate will answer **5 out of 7** questions in Technological study with questions **6** and **7** compulsory.*
- *All the questions of PART I HAVE THE SAME MARKS WHCH IS 4.*
- ***All the candidates*** *shall answer the questions in Part II.*
- *This paper is rated at 40% of the entire paper.*

This paper aims at evaluating the candidates in the following competences:
- Analyze the functioning of mechanical systems;
- Identifying and interpreting the functioning of a part;
- Designing the mechanical links of an assembly;
- Identifying and interpreting a guiding in a mechanism;
- Identify and interpreting of the type of lubrication and sealing
- Identifying and determining the characteristics of a power transmission in a mechanism;
- Realizing a linkage and a guiding;
- Using properly SI system norms in calculations;
- Representing/Interpreting a complex piece taken from a functional mechanism.

THEME: MICRO-BLOCK

I. PRESENTATION

The micro-block (reducer) represented on page 5 is used in handling devices and also when they need:
- a high approach velocity and a small displacement around the working zone.
- a small working speed of work and a high return speed

The user has the choice of the ratios of reduction of the two planetary gears and the screw/wheel couple. Different values are proposed to the designer.

II. FUNCTIONING

1- High velocity

The belt **25** of the reducer of the epicyclical train is maintained fixed in rotation by the intermediary of the screw/wheel couple **34**/**13**, the screw **34** being held fixed by the engine brake **LV** (Low velocity).

2- Low velocity

The pinion **19** is maintained fixed in rotation by the brake of the engine **HV** (High velocity). The belt **25** is pulled in rotation by the intermediary of the wheel **13**, of the screw **34** and of the engine LV.

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3- Conjugated high speed

The two engines **HV** and **LV** turn at the same time with a velocity of 1500 tr/mn. It is known that the shaft **1** turns with a velocity equal to the sum of the **HV** and **LV**. The two velocities used are normally the low velocity and the conjugated high velocity.

Characteristics of the gears

Rep	m	Z
19	2	11
25	2	45
8	3	43
34	3.25	1
13	3.25	41
17	3	10

WORK REQUIRED
PART I: TECHNOLOGICAL STUDY (20 marks)
Question 1: Functional analysis (4 marks)

1. a) Give the names of the elements $\underline{10}$ and $\underline{31}$.   **1 mark**
1. b) Give the functions of $\underline{10}$ and $\underline{31}$.   **1 mark**
1. c) Establish the minimal diagram making sure that the kinematic chain appears.   **2 marks**

Question 2: Types of linkages (4 marks)

There is a rotational link between the shaft $\underline{18}$ and the shaft of the engine **HV**.

2. a) Give two assembly elements that can be used to realize the link?   **1 mark**
2. b) Complete the drawing by mounting the two elements to realize the link.   **3 marks**

Question 3: Functional dimensioning (4 marks)

3. a) Establish the chain of dimension relative to the allowance **J** on the drawing   **1.5 marks**
3. b) Given the following dimensions

      Piece $\underline{21}$: 14 ± 0.1
      Piece $\underline{29}$: 18 ± 0.2
      Piece $\underline{30}$: 7 ± 0.2

Calculate the value of the maximum and minimum allowances.   **2.5 marks**
3. c) Calculate the interval of tolerance.   **0.5 marks**

Question 4: Lubrication and Sealing (4 marks)

4. a) What is the function of $\underline{32}$?   **1 mark**
4. b) Justify the presence of the wing-like elements on the upper part of the casing $\underline{21}$.   **1 mark**
4. c) Justify the presence of the two seals $\underline{2}$ and $\underline{5}$ knowing that the bearing of the left is
lubricated with grease.   **1 mark**
4. d) Which type of seal is referenced $\underline{2}$ and $\underline{5}$?   **1 mark**

Question 5: Guiding (4 marks)

5. a) The bearing $\underline{6}$ has a tolerance dimension as indicated of the assembly drawing. From
the knowledge of mounting of bearing, this tolerance dimension represents which type of fit.   **1 mark**
5. b) The tolerance fit between the bearing $\underline{6}$ and the shaft $\underline{1}$ is indicated on the assembly
drawing. Use it to calculate the maximum and minimum allowances. Use   **2 marks**
$$\emptyset 20 H7 = \emptyset 20 \, {}^{+21}_{0} \qquad \emptyset 20 p6 = \emptyset 20 \, {}^{+35}_{+22}$$

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5. c) Use the values to conclude on the type of fit.   **1 mark**

Question 6: Power transmission technology (4 marks)

6. a) What is the type of power transmission between piece **17** and **25**?   **1 mark**

6. b) Which mode of power transmission between pieces **17** and **25**?   **1 mark**

6. c) Use the information on table 1 above to calculate
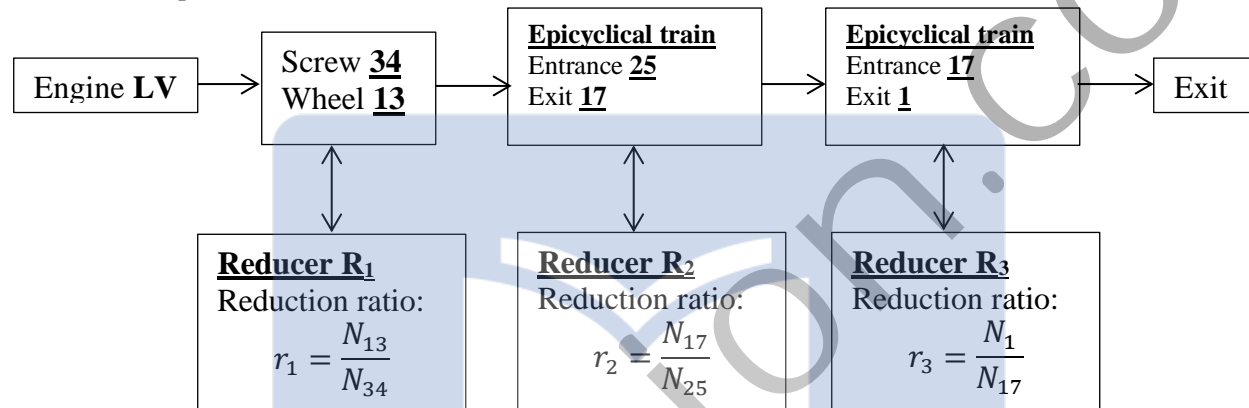
      i) The pitch diameters of **17** and **25**

      ii) The outside diameters of **17** and **25**

      iii) Distance between the two axes.   **2 marks**

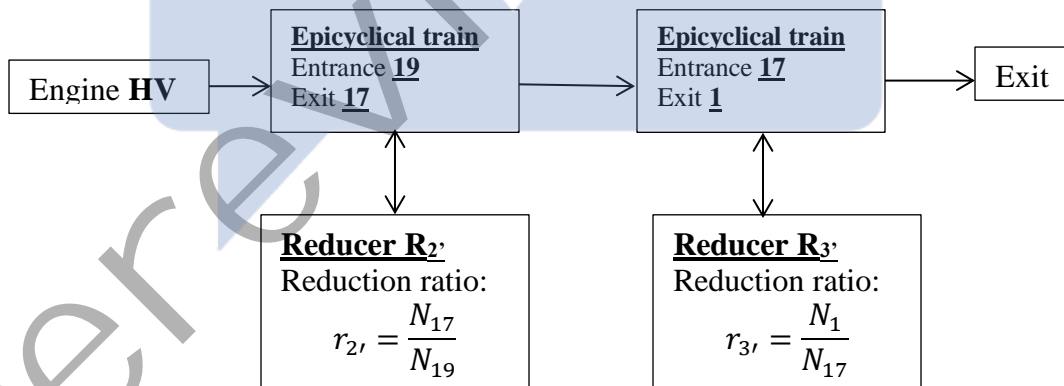**Question 7: Power transmission calculation (4 marks)**

7. a) Consider the case where the engine **LV** is stopped (velocity is zero). The kinematic chain will be decomposed into three reducers as shown below

Engine **LV** →	Screw **34** Wheel **13** →	**Epicyclical train** Entrance **25** Exit **17** →	**Epicyclical train** Entrance **17** Exit **1** →	Exit

Reducer R$_1$ Reduction ratio: $r_1 = \dfrac{N_{13}}{N_{34}}$	**Reducer R$_2$** Reduction ratio: $r_2 = \dfrac{N_{17}}{N_{25}}$	**Reducer R$_3$** Reduction ratio: $r_3 = \dfrac{N_1}{N_{17}}$

Calculate r$_1$, r$_2$ and r$_3$.   **2.5 marks**

7. b) Consider the case where the engine HV is stop (velocity is zero). The kinematic chain will be decomposed into two reducers as shown below

Engine **HV** →	**Epicyclical train** Entrance **19** Exit **17** →	**Epicyclical train** Entrance **17** Exit **1** →	Exit

Reducer R$_{2'}$ Reduction ratio: $r_{2'} = \dfrac{N_{17}}{N_{19}}$	**Reducer R$_{3'}$** Reduction ratio: $r_{3'} = \dfrac{N_1}{N_{17}}$

Calculate r$_{2'}$.   **1.5 marks**

Useful formulae for question 7

$$\frac{N_{25}-N_{17}}{N_{19}-N_{17}} = (-1)^1 \frac{Z_{19.}}{Z_{25}} \frac{Z_{37}}{Z_{37}}$$

$$\frac{N_{17}-N_{28}}{N_8-N_{28}} = (-1)^1 \frac{Z_{36.}}{Z_{17}} \frac{Z_8}{Z_{36}}$$

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PART II: GRAPHICAL STUDY (30 marks)

1. **REALIZATION OF LINKAGES AND GUIDING** **(15 marks)**

   The screw 34 is mounted on a double row ball bearing of oblique contact. To guarantee the guiding of this screw in rotation, a cylindrical roller bearing 30 RU 02 (dimensions: 30 x 62 x 16) should be mounted on the other extreme. Complete the mounting of this bearing. Take note that the internal shape of the casing has been modified to mount the bearing and seal. The seal should be mounted just with the normalized symbol.

2. **REPRESENTATION OF A FINISHED PRODUCT** **(15 marks)**
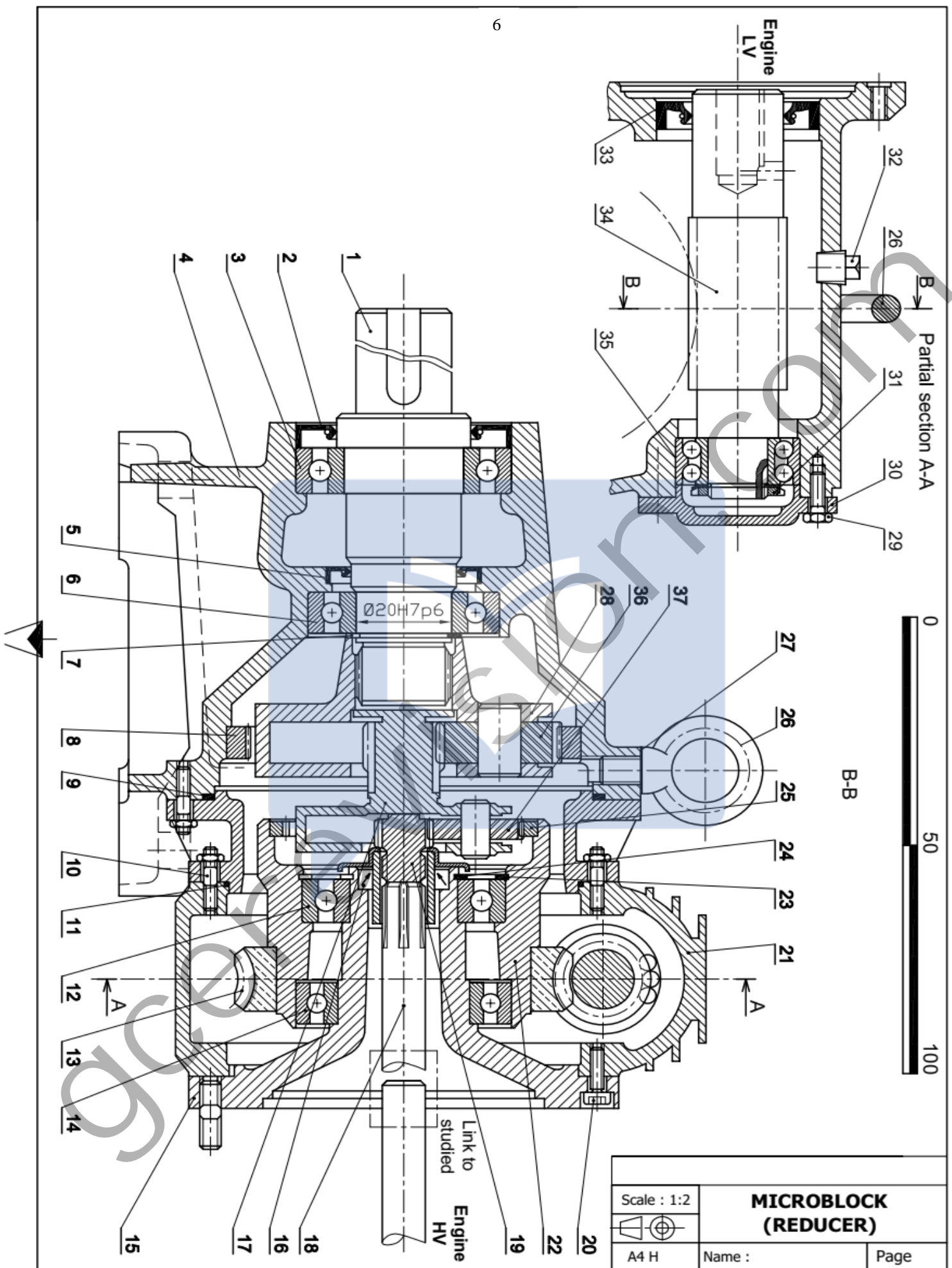
   Draw the definition drawing of the casing 21 at scale 1:2

   a) Face view section B – B,

   b) Right view half section A – A.

   Preview an opening for draining and take note of the following.

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Engine LV

Partial section A-A

B-B

33
32
34
35
26
31
30
29

4
3
2
1

5
6
7
8
9
10
11
12
13
14

Ø20H7p6

37
36
28

27
26
25
24
23
21

A
A

Engine HV

Link to studied

15
17
16
18
19
22
20

0
50
100

Scale : 1:2	**MICROBLOCK**	
---	(REDUCER)	
A4 H	Name :	Page

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Rep.	Nber	Designation	Material	Observation
37	1	Satellite		
36	1	Satellite		
35	1	Ball bearing SKF 3205		
34	1	Screw		
33	2	Seal		
32	1	Screw		
31	1			
30	1	Cover		
29		Screw H		
28	1	Satellite carrier		
27	2	Seal		
26	2			
25	1	Belt		
24	1	Retaining ring		
23	1	Retaining ring		
22	1	Belt carrier		
21	1	Casing		
20	3	Screw		
19	1	Planetary		
18	1	Entrance shaft for engine HV		
17	2	Satellite carrier		
16	1	Seal		
15	1	Casing		
14	1	Ball bearing SKF 6011		
13	1	Returned toothed wheel		
12	1	Ball bearing SKF 6209		
11	1	Seal		
10	6			
9	1	Seal		
8	1	Belt		
7	1	Retaining ring		
6	1	Ball bearing SKF 6208		
5	1	Seal		
4	1	Casing		
3	1	Ball bearing SKF 6210		
2	1	Seal		
1	1	Shaft		
Rep.	Nber	Designation	Material	Observation

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ANSWER FILE FOR SECTION A

PART I : TECHNOLOGICAL STUDY

Question 1: Functional analysis

1.a) Names of the element **10**

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……………………………………………………………………………………………....................................

Names of the element **31**.

……

……

1.b) Give the function of **10**

……..

……

Give the function of **31**

……..

……

1. c) Establish the minimal diagram making sure that the kinematic chain appears.
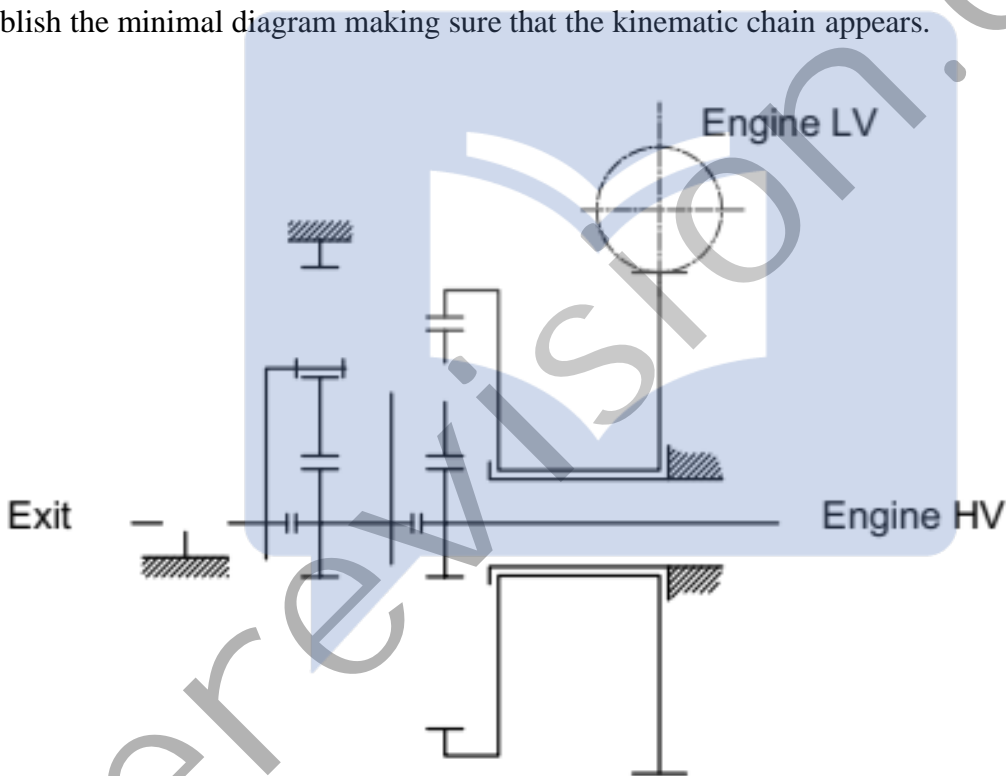
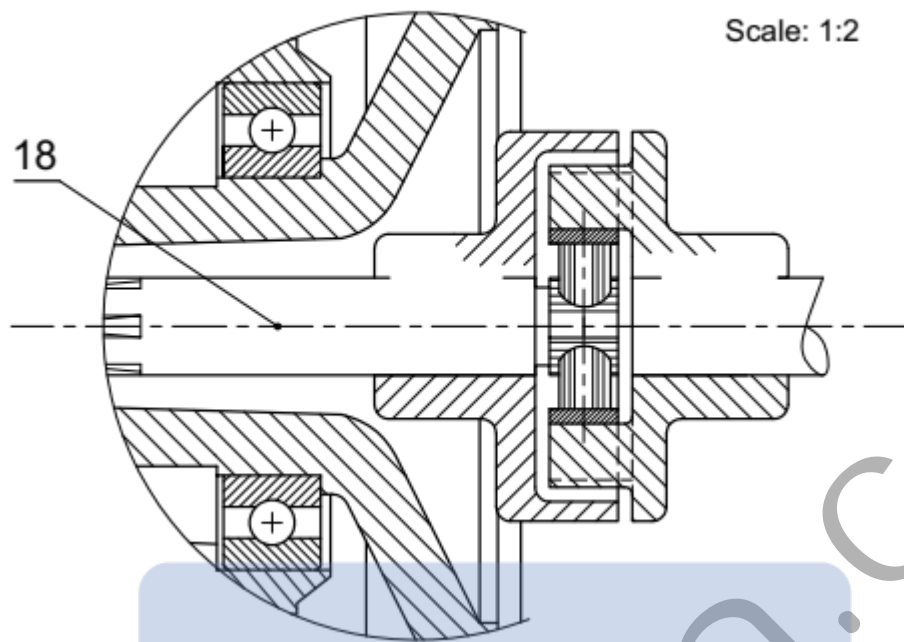**Question 2: Types of linkages**

There is a rotational link between the shaft **18** and the shaft of the Engine **HV**.
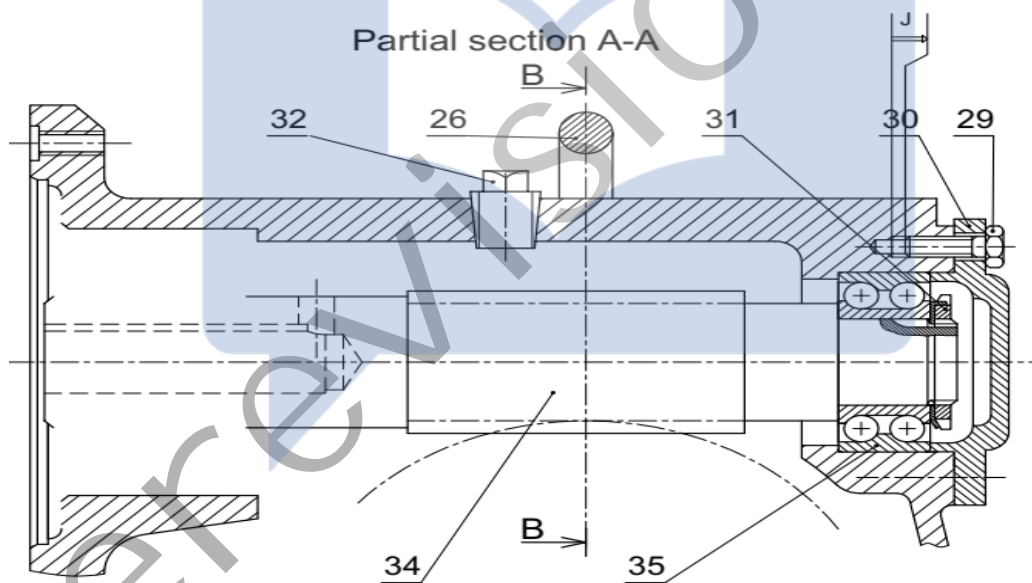
2. a) Two assembly elements

……

……

………..

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2. b) Completion of the drawing

Scale: 1:2

18

Question 3: Functional dimensioning

3. a) Establishment of the chain of dimension

Partial section A-A

32   26   31   30   29

B

J

34   B   35

3. b). Calculation of the maximum and minimum allowances.

………
………
………
………
………
………

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3. c) Calculation of the interval of tolerance

………………………………………………………………………………………………………
……………………………………………………………………………………………………….

Question 4: Lubrication and Sealing

4. a) Function of **32**?

………………………………………………………………………………………………………
………………………………………………………………………………………………………
……………………………………………………………………………………………………….

4. b) Justification of the presence of the wing-like elements on the upper part of the casing **21**.

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4. c) Justification of the presence of the two seals **2** and **5**

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……………………………………………………………………………………………………….

4. d) Type of seal is referenced **2** and **5**?

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………………………………………………………………………………………………………
……………………………………………………………………………………………………….

Question 5: Guiding

5. a) The bearing **3** has a tolerance dimension a indicated of the assembly drawing. From the knowledge of mounting of bearing, this tolerance dimension represents which type of fit.

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……………………………………………………………………………………………………….

5. b) calculation of the maximum and minimum clearances

………………………………………………………………………………………………………
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………………………………………………………………………………………………………
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5. c) Conclusion on the tolerance

………………………………………………………………………………………………………
……………………………………………………………………………………………………….

Question 6: Power transmission

6. a) Type of power transmission between piece **17** and **25**?

………………………………………………………………………………………………………
………………………………………………………………………………………………………
………………………………………………………………………………………………………

6. b) Mode of power transmission between pieces **17** and **25**?

………………………………………………………………………………………………………
………………………………………………………………………………………………………
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6. c) i) calculation of the pitch diameters of **17** and **25**

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……

ii) calculation of the outside diameters of **17** and **25**

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……
……
……

iii) calculation of the distance between the two axes

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……
……

Question 7: Power transmission calculation

7. a) Calculation of r_1

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……
……

Calculation of r_2

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……
……

Calculation of r_3.

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……
……
……

7. b) Calculation of $r_{2'}$

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……
……

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2. GRAPHICAL STUDY: Realization of linkages and guiding

Partial section A-A

Scale : 1:1		Date :
⊲─⊕		
A4	Name :	

2019/7145/3/C
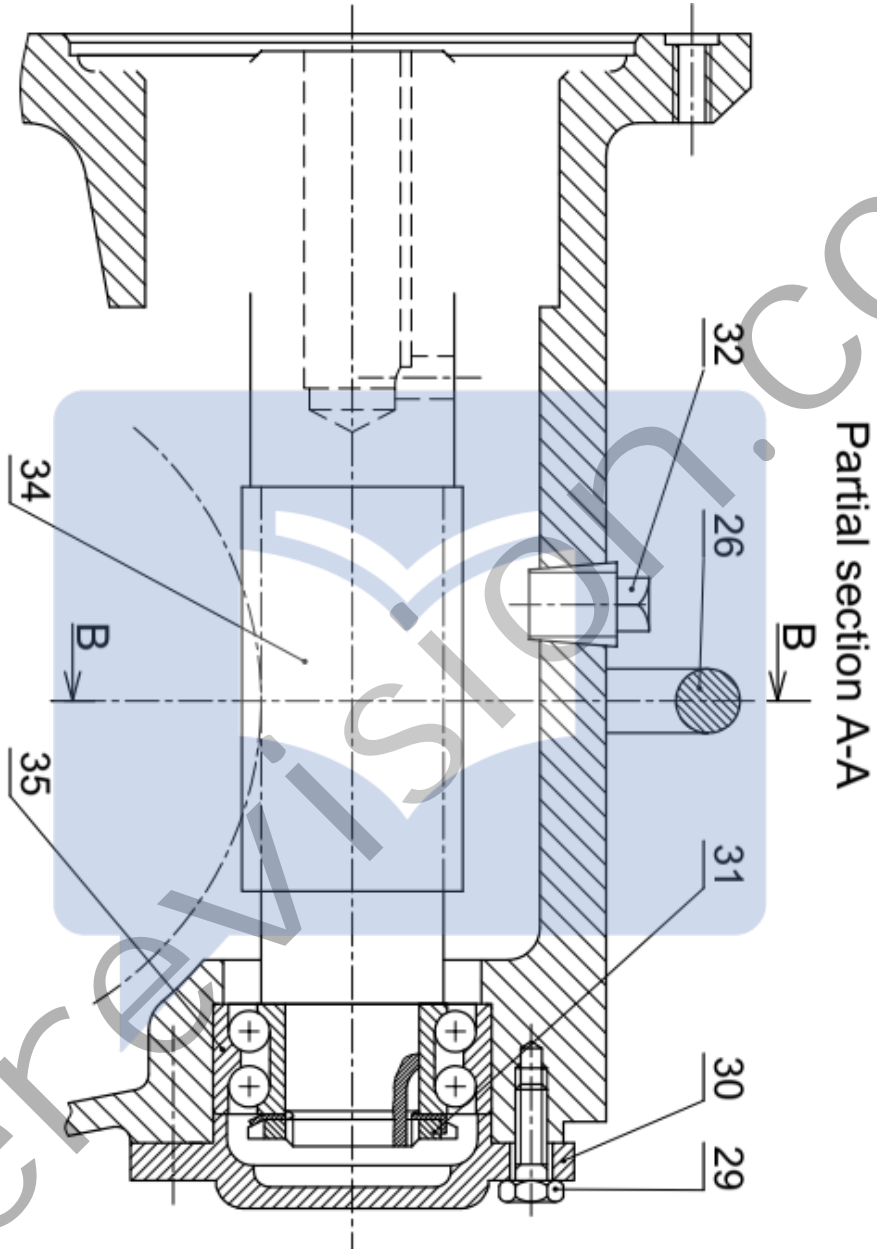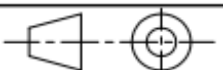
2. GRAPHICAL STUDY: Presentation of a finished product (casing <u>21</u>)

Half section A-A

B-B
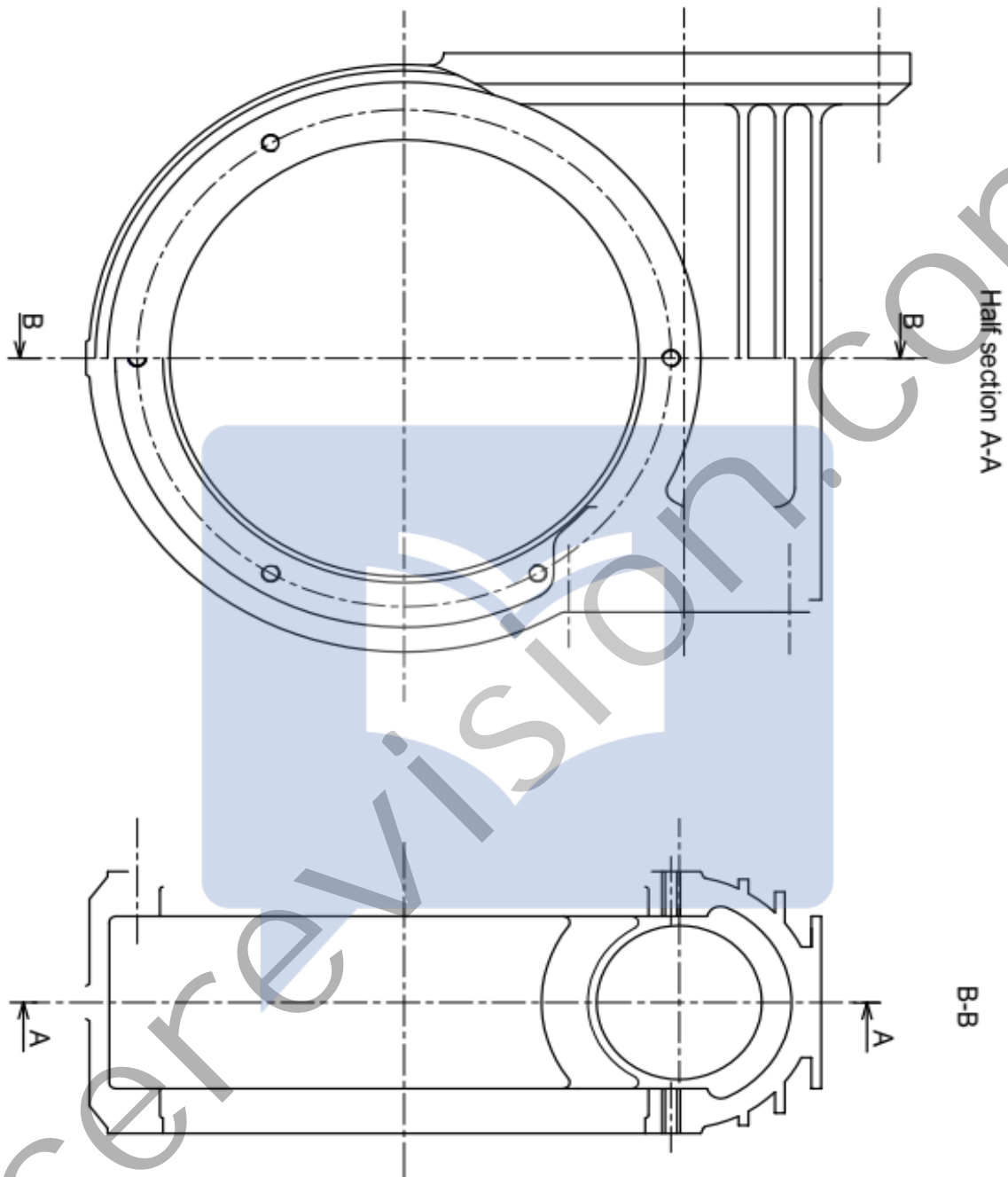
Scale : 1:2	CASING 21	Date :
A4	Name :	Page

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SECTION B

METAL WORK AND INDUSTRIAL PIPING (MWIP)

AUTORIZED DOCUMENTS
- No document is authorized
- Drawing instruments and calculator

INSTRUCTION TO CANDIDATES

- The paper is presented as **PART I, II and III**
- Part I is steel construction work, Part II tanking and Part III piping
- Answer ALL the question on part I, II and III
- Carefully read the instructions on each part before commencing
- This paper carries 35% of the total marks

   Two pre-prepared answer sheets of A3 size and a graph paper A3 size will be given to each candidate

SETTING.

The study concerns the installation of an awning at the entrance of an industrial building in order to adapt it to new activities.
The two figures below represent:
- Part of the building with the frame of the awning that is adapted to the A3 entrance
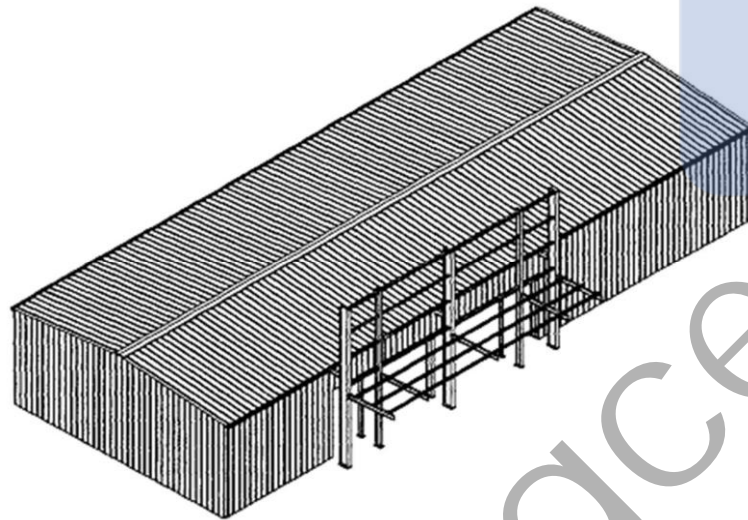
The frame of the awning and the gantry of the building to which it is connected.
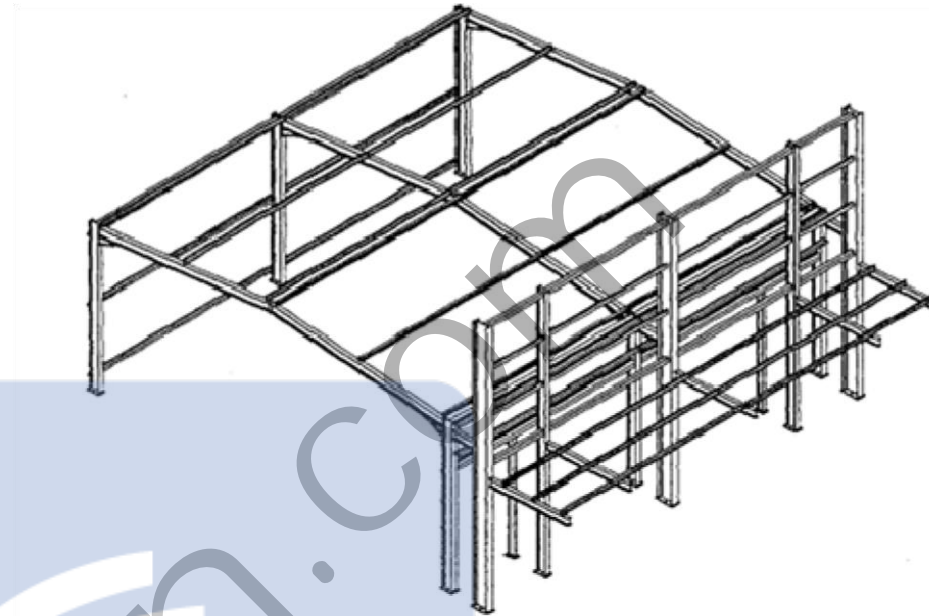
PART I: STRUCTURAL STEEL WORK   /35 Marks

1. The mounting of the crossbar (C) on the pole (A1) of the awning. The link will be made by a double angle bar 80x80x6 of length 150mm, assembled by three ordinary bolts H M 16 on (C), and six ordinary bolts H M16 on (A1).
       The link must allow a vertical translation of $\pm$ 20 mm from (A1) with respect to (C) in order to facilitate the assembly, for that reason provide oblong holes on (A1) that you will represent on the following view G.

2.   The assembly of the crossbar (A2) on the pole (A1) of the awning. Provide a plate (270x160x10) welded to the end of (A2).
       The connection will be provided by six ordinary bolts H M16, four arranged between the wings of (A2) and the other two above the upper wing. Provide a medial gusset (thickness.6) to stiffen the connection between the plate and the upper wing on (A2). Represent the plate and gusset in the following view D.

:

FRAMEWORKS :

    Awning (reference A1,.........A9)
    Building (partial, reference B1, B2, B3)

Link (reference C)

Scale 1/50

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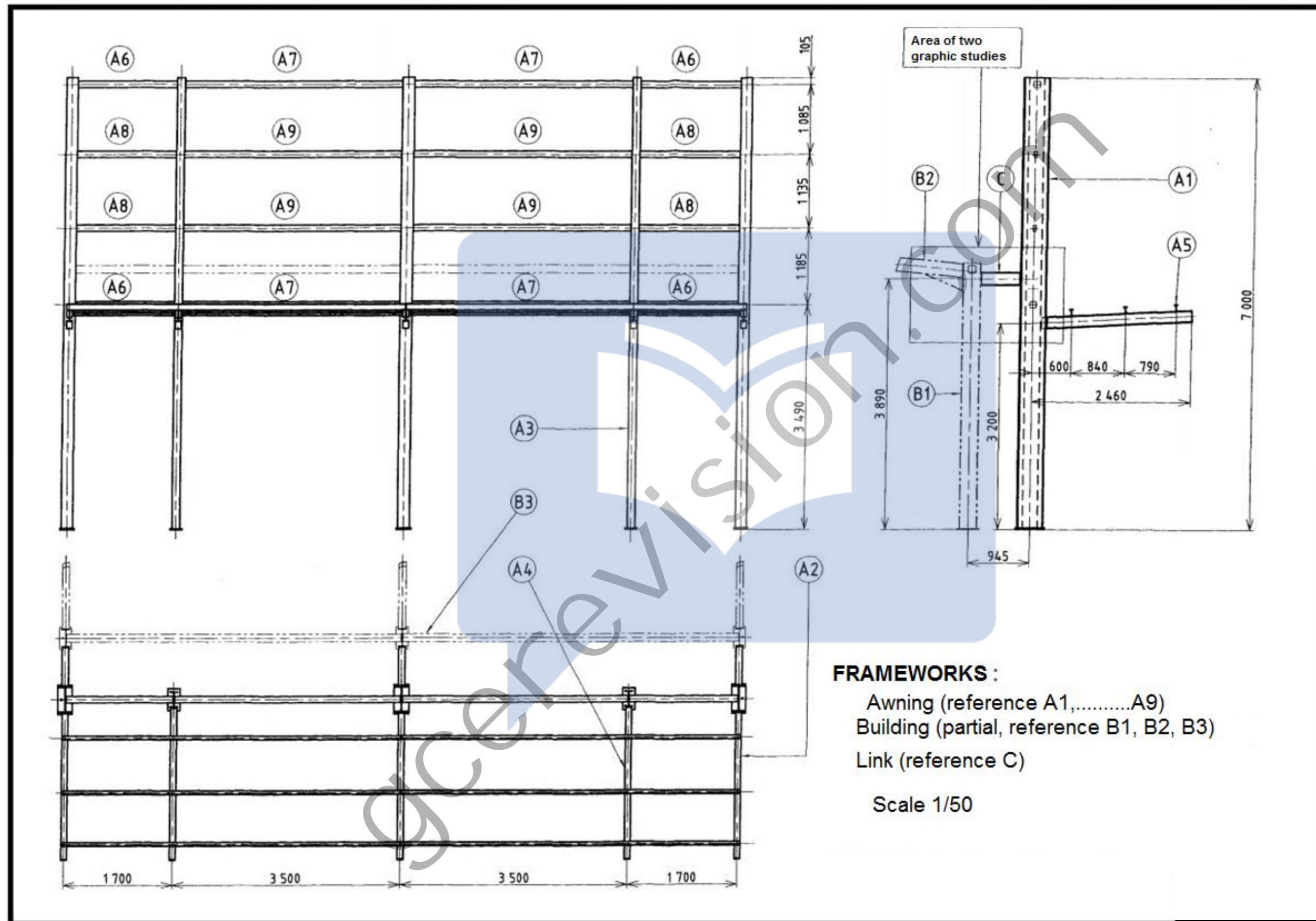
PARTIAL LIST OF ITEMS

FRAMEWORK LINK					
C	3	Cross member	IPE 200	S235	Axes 1, 3, 5
BULDING FRAMEWORK					
B3	2	Beam	Tube 120 X120 X3,2	S235	
B2	3	Cross member	IPE 220	S235	Axes 1,3,5
B1	3	Post	IPE 270	S 235	Axes 1,3,5
AWNING FRAMEWORK					
A9	4	Beam	Tube 50 X100X3,2	S235	
A8	4	Beam	Tube 50 X100X3,2	S235	
A7	4	Beam	Tube 100 X100X3,2	S235	
A6	4	Beam	Tube 100 X100X3,2	S235	
A5	6	Purlin	IPE 100	S235	
A4	2	Cross member	IPE 180	S235	Axes 2 and 4
A3	2	Post	IPE 240	S235	Axes 2 and 4

A2	3	Cross member	IPE 180	S235	Axes 1,3,5
A1	3	Post	IPE 400	S235	Axes 1,3,5
Ref.	Nb.	Designation	Profil	Material	Observation
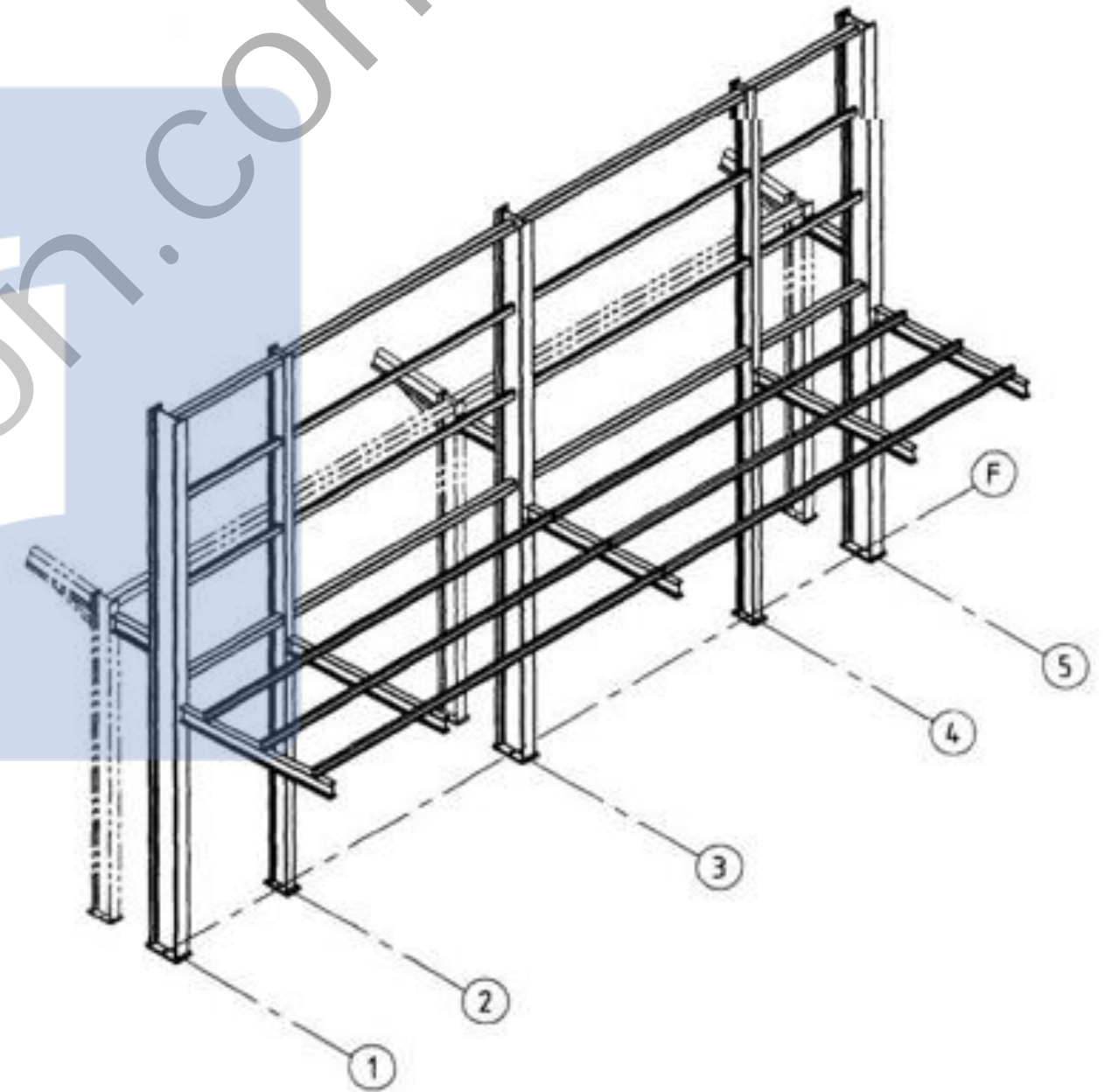
PITCH AND MARGINAL PITCH

The longitudinal direction corresponds to the direction of the effort necessary for assembly
Longitudinal direction: e_1 and p_1
Transversal direction: e_2 and p_2
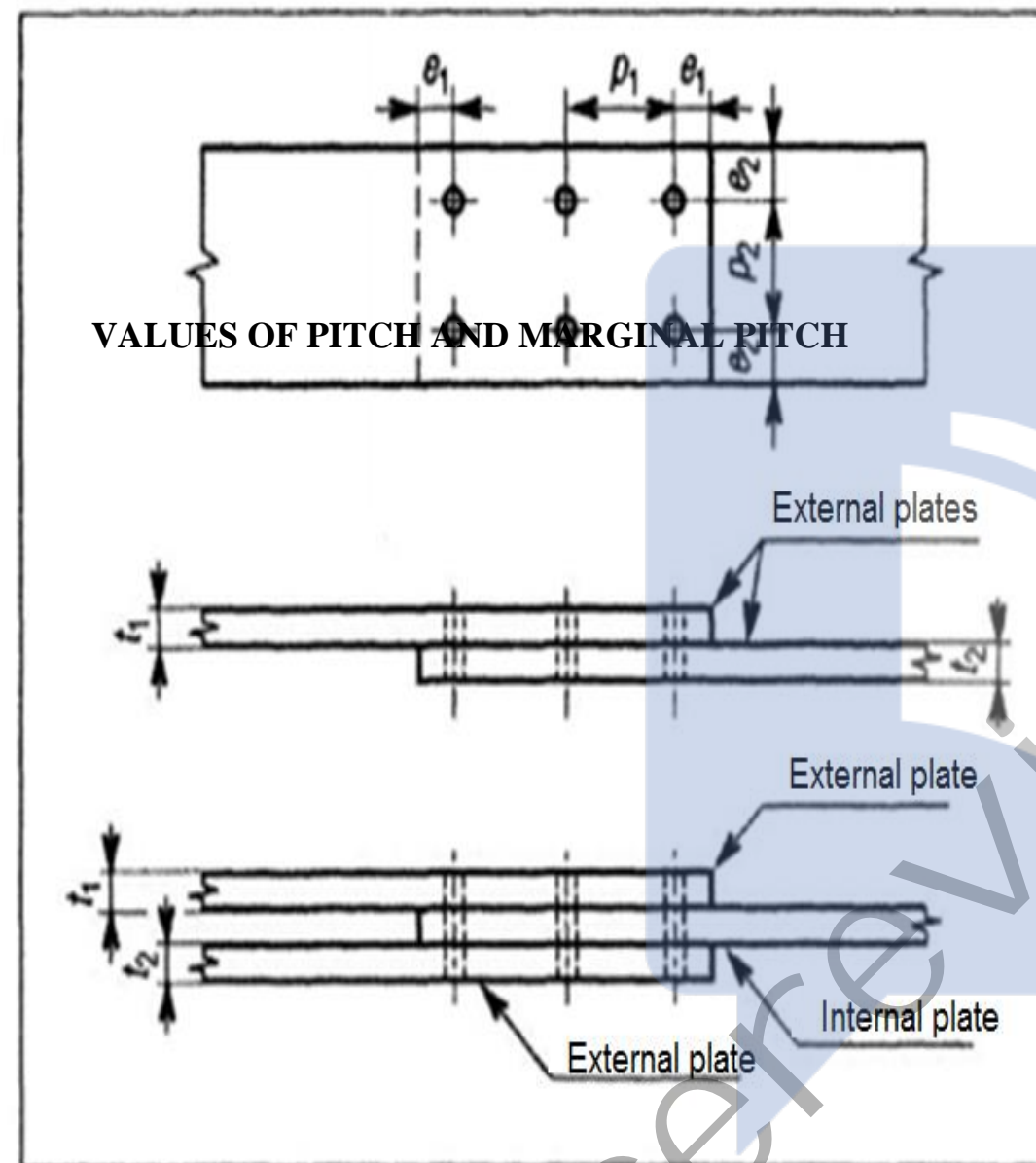
VALUES OF PITCH AND MARGINAL PITCH

Definition of pitch and marginal pitch

	Element	File	Minimum(mm)		Maximum (mm)
			Ordinary Bolt	HR Bolt	
e_1			$1.2\ d_0$ (1)	$1.5\ d_0$	max (12 t or 150) (2)
e_2			$1.5\ d_0$ (3)		idem e_1
p_1	compressed		$2.2\ d_0$ (1)		min (14 t or 200) (5)
	tensed	External	$2.2\ d_0$ (1)		min (14 t or 200) (4)
		internal	$2.2\ d_0$ (1)		min (28 t or 200) (4)
p_2	Compressed and tensed		$3\ d_0$ (6)		min (14 t or 200) (5)

d_0 : diameter of the hole , t : thickness of thinnest plate

(1) Value to be increased to obtain an adequate resistance to the diametric pressure.
(2) In case of bad weather or risk of corrosion, take 40mm + 4t.
(3) Take $1.2\ d_0$ by reducing the calculated resistance at the diametric pressure accordingly.
(4) Multiply by 1.5 if the elements are neither exposed to bad weather nor other corrosion risks.
(5) To be limited to avoid the local interactions between the fastened elements.
(6) Take $2.4\ d_0$ by reducing the calculated resistance at the diametric pressure accordingly.

ANSWER SHEET FOR PART I

Scale 1/5

GRAPHICAL STUDY 2

G VIEW

G → (C) IPE 200

(A1) IPE 400

D VIEW

(A2) IPE 180   D

Angle bar 80X80X6
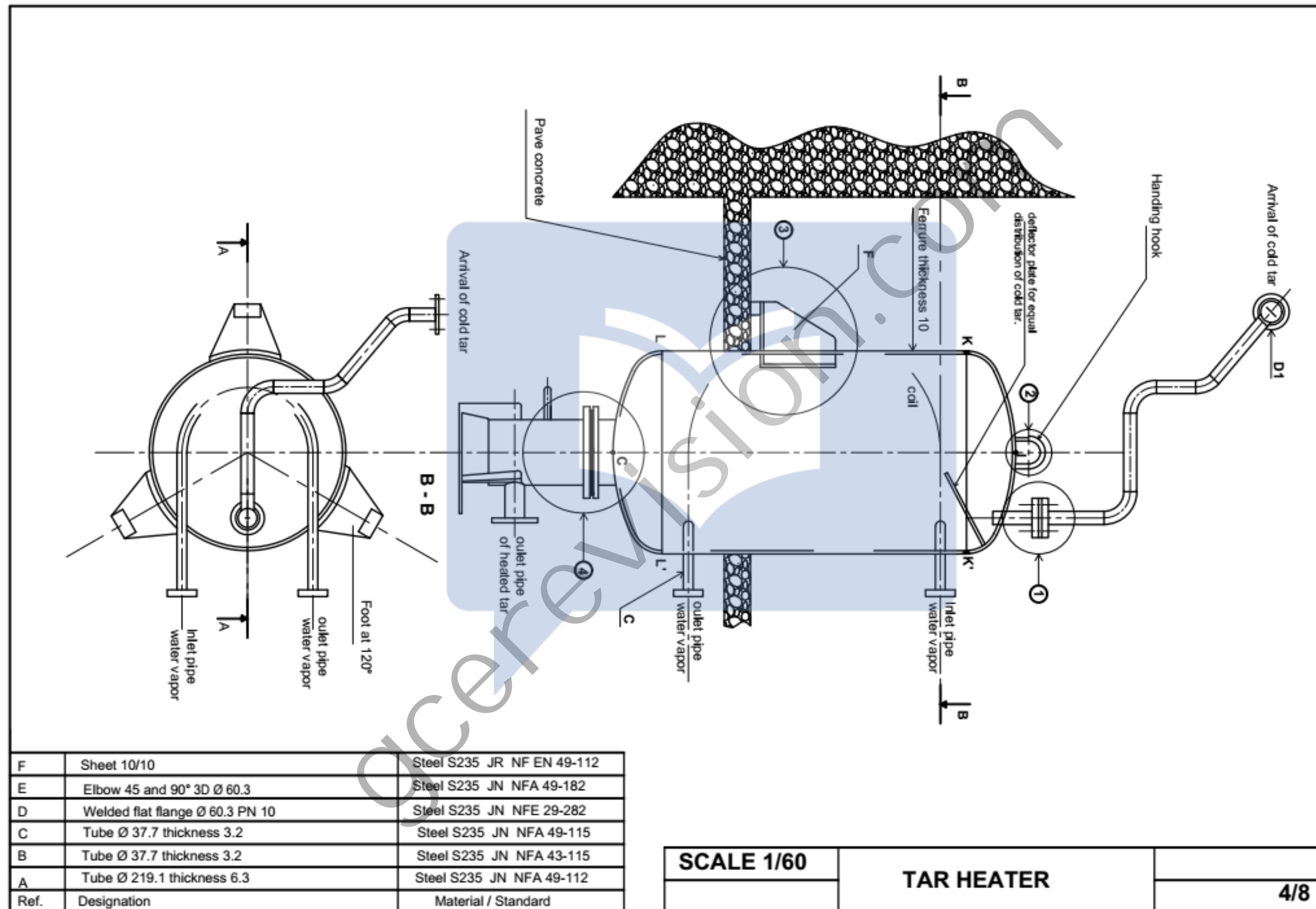
Scale 1/5

19,5

2019/7145/3/C
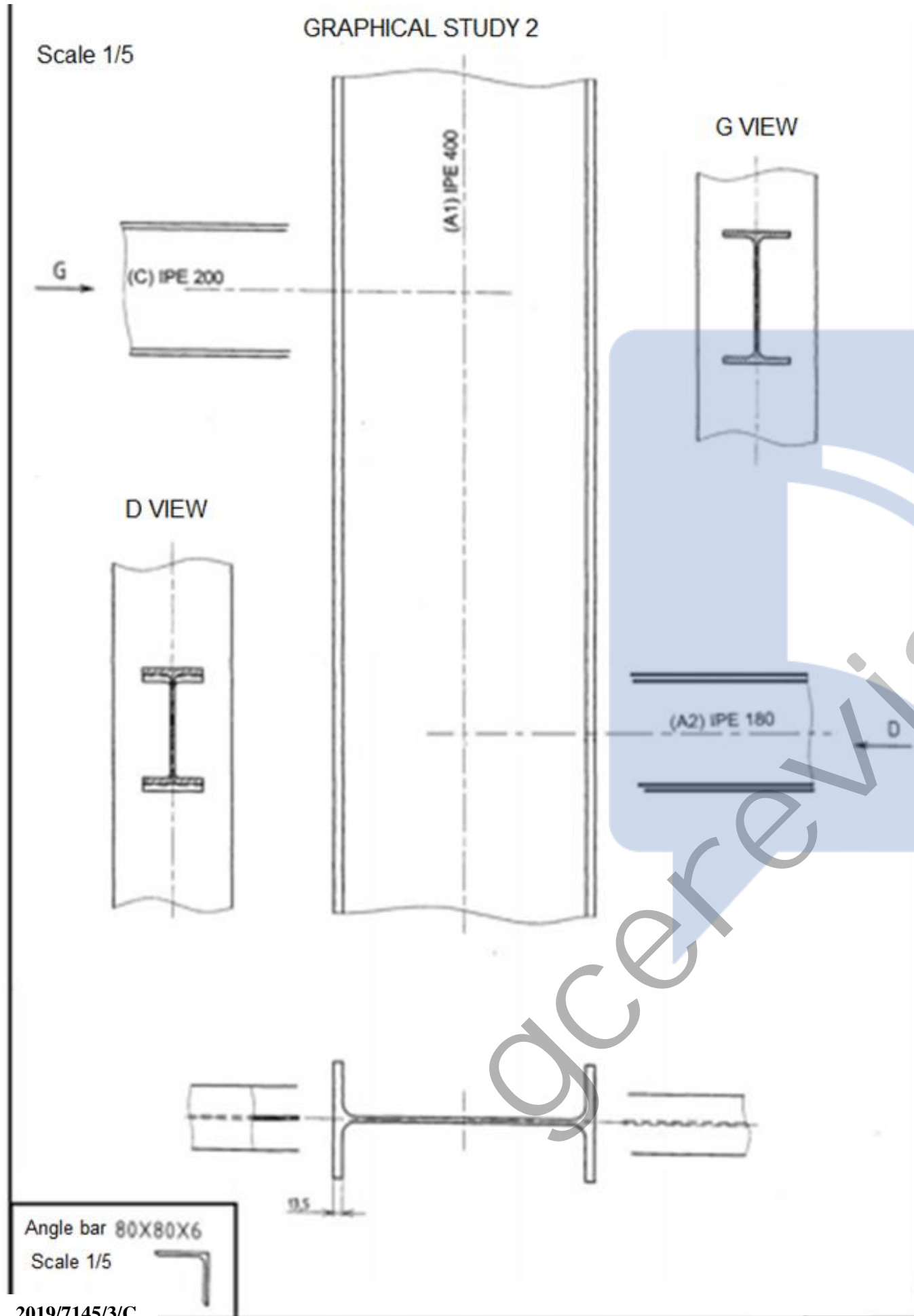
PART II: INDUSTRIAL TANKING   /35 Marks

On the answer sheet, on the scale 1: 4, complete the drawing of a lifting lug. Use a thickness plate of 8mm and 80mm width for the fixation.
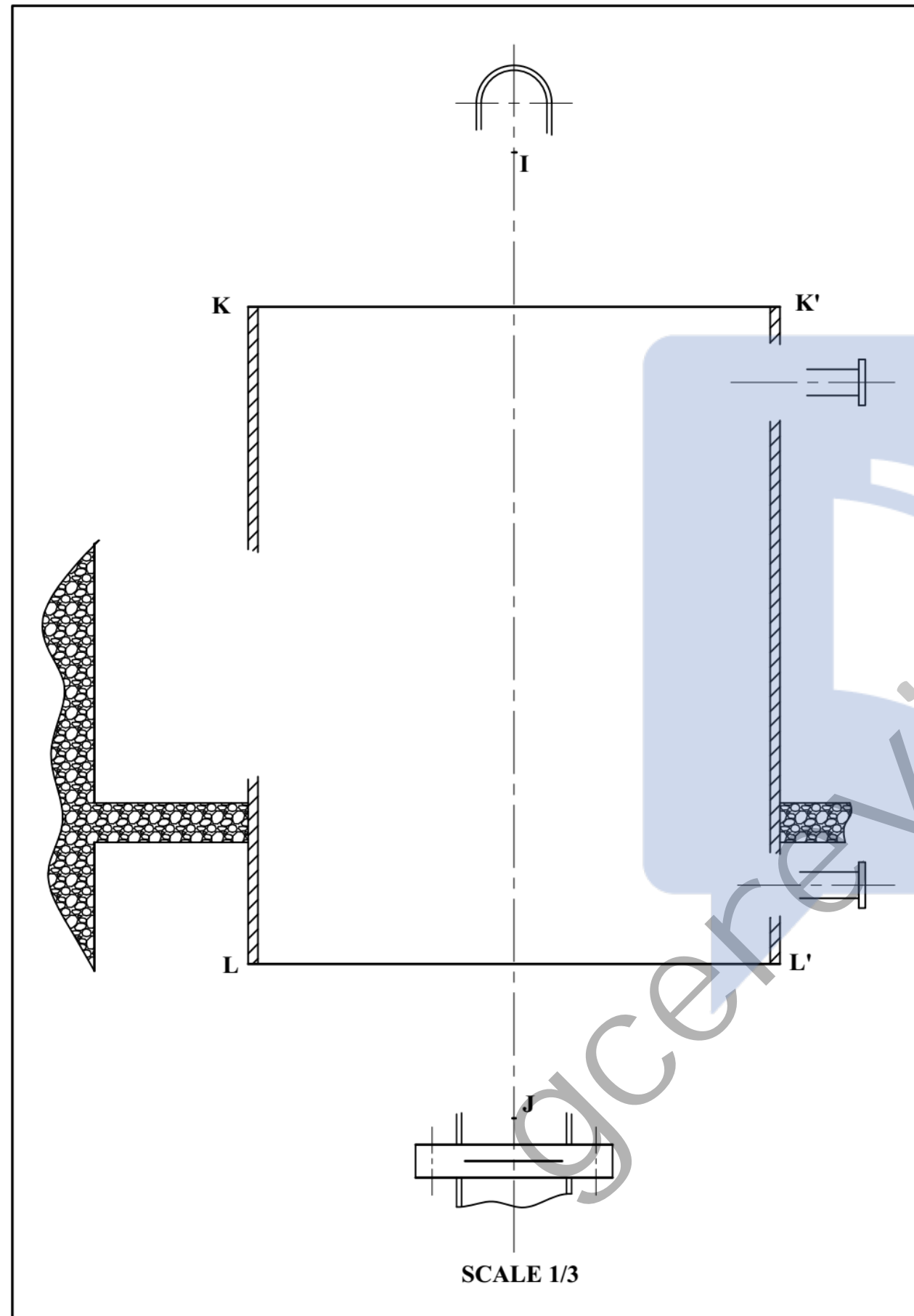
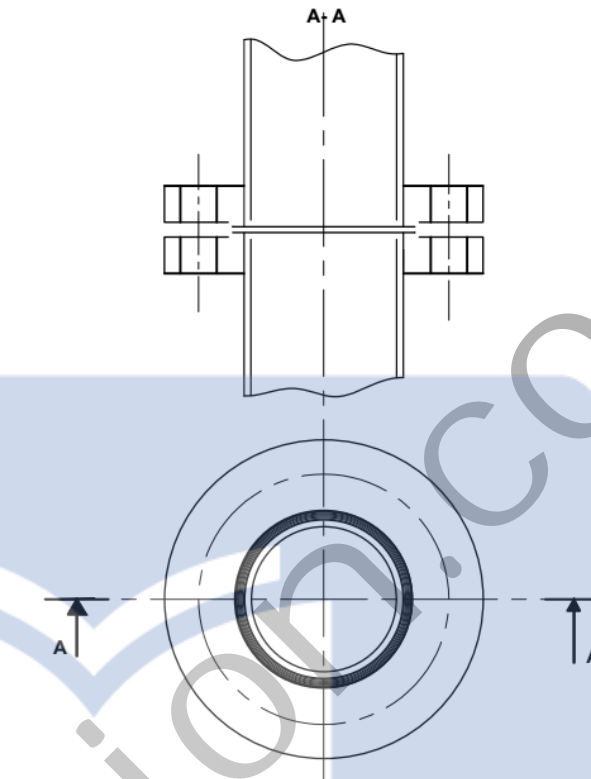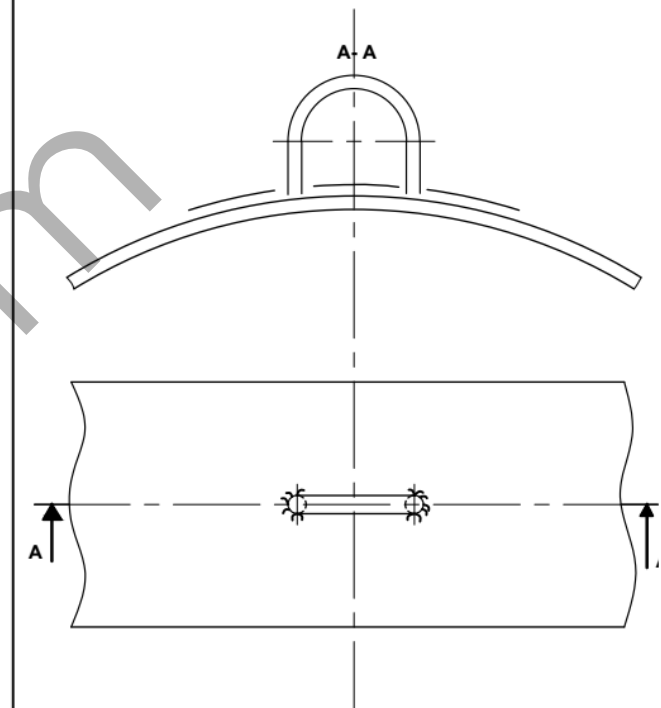The thickness of the lifting lug is 20mm.

Dimension and welding are requested.

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19/

F	Sheet 10/10	Steel S235 JR NF EN 49-112
E	Elbow 45 and 90° 3D Ø 60.3	Steel S235 JN NFA 49-182
D	Welded flat flange Ø 60.3 PN 10	Steel S235 JN NFE 29-282
C	Tube Ø 37.7 thickness 3.2	Steel S235 JN NFA 49-115
B	Tube Ø 37.7 thickness 3.2	Steel S235 JN NFA 43-115
A	Tube Ø 219.1 thickness 6.3	Steel S235 JN NFA 49-112
Ref.	Designation	Material / Standard

SCALE 1/60

TAR HEATER

4/8

2019/7145/3/C

ANSWER SHEET FOR PART II

DETAIL 1

DETAIL 2

K   K'

I

A·A

A·A

A

A

A

L   L'

J

DETAIL 3

DEFINITION DRAWING

A

A

A·A

B   B

SCALE 1/3

2019/7145/3/C

6/8
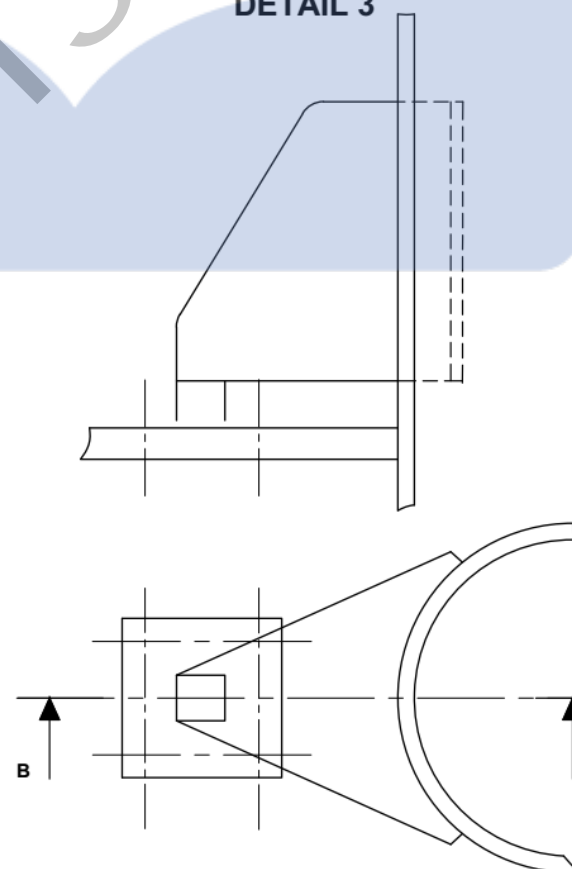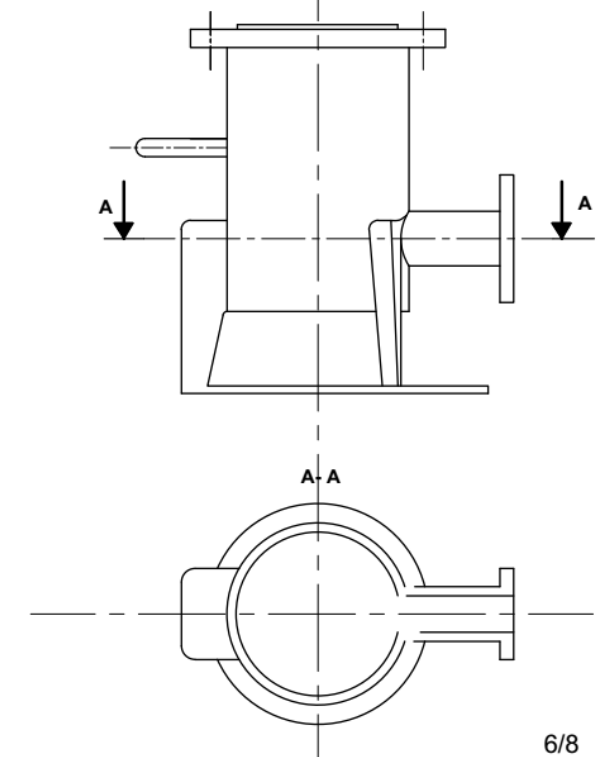
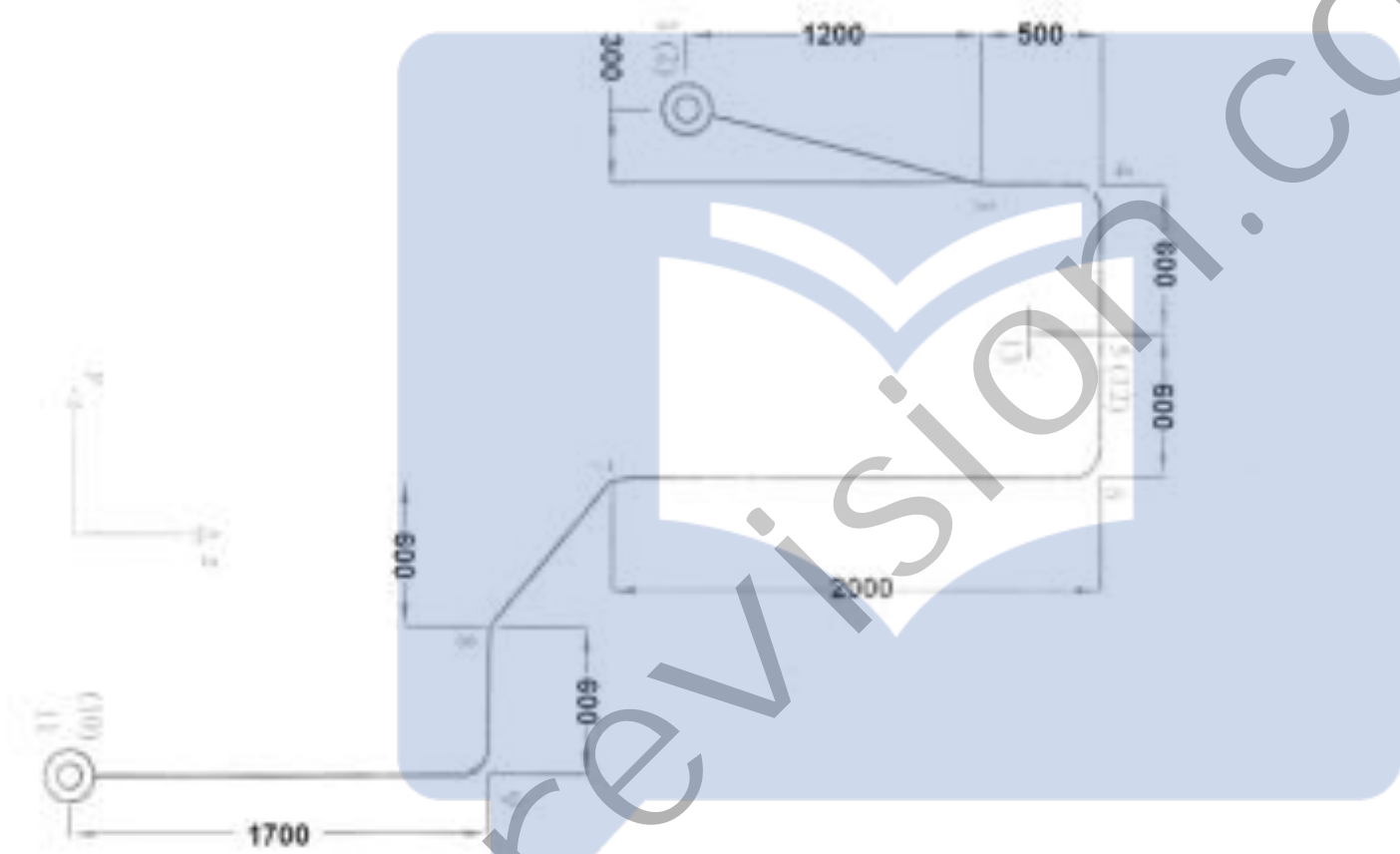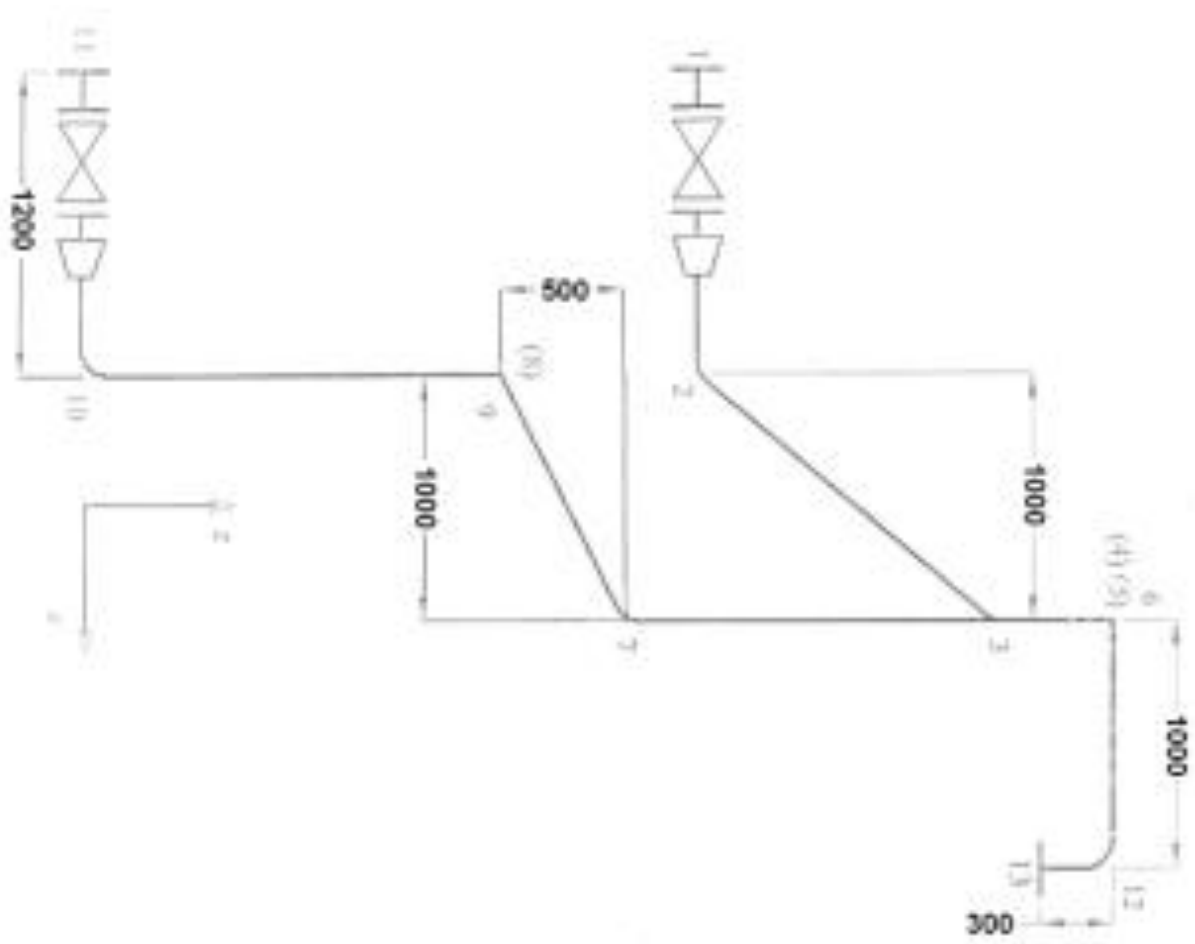## PART III: INDUSTRIAL PIPING   /30 Marks

The pipe line is used in petroleum industry to transport fluid. Use scale 1/25 to represent the isometric view of this pipeline.

2019/7145/3/C

2019/7145/3/C

ANSWER SHEET FOR PART III

2019/7145/3/C