STUDENT NUMBER: .....

STUDENT NAME: .....

2014

Higher School Certificate

Preliminary Examination

Engineering Studies

General Instructions

- Reading time – 5 minutes
- Working time-2 hours
- Board approved calculators may be used
- Write using black or blue pen
- Draw diagrams using pencil
- Write your student number and/or name at the top of every page
- A formulae sheet is provided

Total marks- 70

Section I – Pages 3-8
20 marks

- Attempt Questions 1-20
- Allow about 30 minutes for this section

Section II – Pages 9-17
50 marks

- Attempt Questions 21-23
- Allow about 1 hour and 30 minutes for this section

This paper MUST NOT be removed from the examination room

STUDENT NUMBER/NAME: .....

Section I

20 marks
Attempt Questions 1-20
Allow about 30 minutes for this section

Select the alternative A, B, C or D that best answers the question and indicate your choice with a cross (X) in the appropriate space on the grid at the back of this examination.

	A	B	C	D
1				
2				
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20				

1 A low melting point alloy used for joining electrical wires and components is known as:

(A) Acrylic
(B) Resin
(C) Alloy
(D) Solder

2. Fazlur Khan is best known for which innovation?

(A) The first propeller-driven iron-hulled ocean going ship.
(B) The alternating current induction motor.
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3. Which statement best describes an *equilibrant force?*

(A) The equilibrant force has the same magnitude, direction and sense as the resultant and produces equilibrium in the object.
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(A) The metal becomes harder as slip planes are reduced due to dislocation growth subsequent tangling.
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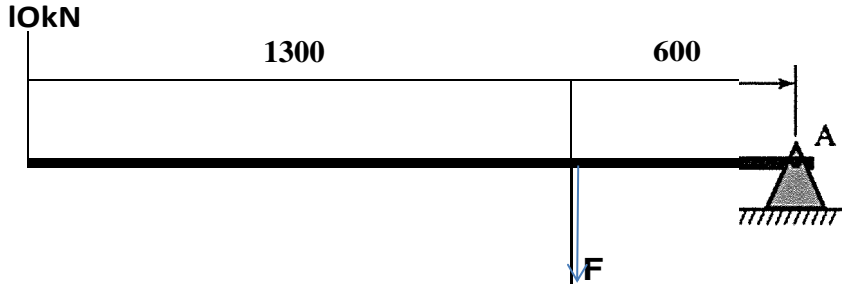
(A) 0.2

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(D) 1.1

6 What is the force, F, acting on the lever pivoting at A, when a 10 kN force is applied as shown?



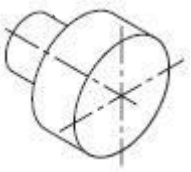
(A) 21.62kN

(B) 31.67 kN

(C) 42.51 kN

(D) 60.32 kN

7. Select the correct engineering term for this part:



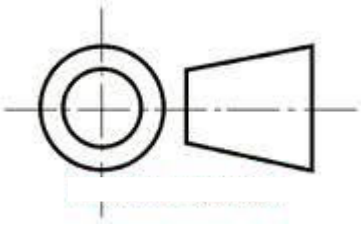
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(A) A pictorial drawing showing isometric, oblique or orthogonal third angle projection

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(A) 30MPa

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(C) 22MPa

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10. What is the mechanical advantage of a machine if a 30N effort lifts a 20kg load?

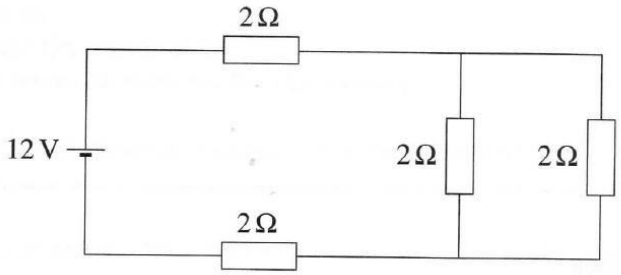
(A) 0.666

(B) 1.5

(C) 6.66

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11. A simple electric circuit is shown.



What is the total current in the loaded circuit?

(A) 1.5 A

(B) 2.4 A

(C) 3.0 A

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12. The metallic crystal structure which allows the most slip planes is:

(A) Face Centered Cubic

(B) Body Centered Cubic

(C) Hexagonal Close packed

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13. Which of the following defines ability of a material to withstand stress without failure?

(A) Hardness

(B) Toughness

(C) Stiffness

(D) Strength

14. Which of the following describes AC and DC electrical currents?

(A) AC periodically reverses direction and DC is a flow of electrical charge in only one direction.

(B) AC is the only current used in our homes while DC is only used in portable appliances.

(C) AC can only be produced in a coal fired power station while DC can be produced by rectifying AC.

(D) AC is more dangerous than DC because AC always has a higher voltage.

15. Which describes the forces acting on a body that is in *equilibrium?*

(A) All vertical forces and horizontal forces acting on the body will all pass through the same point.

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(C) A maximum stress that can be produced in the material without failure occurring

(D) A maximum stress that can be produced in the material before its elastic limit occurs.

17. Fillers used in brake pads are best described as materials that;

(A) Are generally low cost, such as glass or steel that are added to extend the material in the composite and occupy space.

(B) Are generally low cost materials such as clay or calcium carbonate that are added to extend the material in the composite, occupy space and reduce costs.

(C) Are generally Metal chips, used to modify friction properties and to control cleanliness on the brake interface.

(D) Are generally low cost and are used to reduce friction.

18. Which two values determine the force of friction required, if an object is just on the verge of sliding on a surface?

    (A) The coefficient of friction of the roughest surface and the weight of the object

    (B) The coefficient of friction of the plane and the slope of the plane on which the object tends to move

    (C) The coefficient of friction of the two surfaces and the normal reaction

    (D) The coefficient of friction of the surface and the magnitude of the force pushing the object

19. Effective dissipation of heat energy is important in braking systems to:

    a keep the driver warm in winter

    b allow the conversion of kinetic energy to heat energy to continue during heavy braking operations.

    c allow the drums/discs to stay hot during braking.

    d allow fade when braking.

20. What is the name of the material that forms when steel with 0.6% carbon content is heated to red heat and then quenched in water?

    (A) Cast iron

    (B) Annealed steel

    (C) Martensite

    (D) Cementite

STUDENT NUMBER/NAME: ……

Section II

45 marks
Attempt Questions 21-23
Allow about 1 hour and 30 minutes for this section

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of the response.

Question 21 – Engineering Products (15 marks) **Marks**

Two engineered products from different times are shown below. The toaster on the left is from the 1950's and the toaster on the right is from the present day.





(a) (i) Name and explain TWO significant effects on people's lives using the modern toaster in comparison to the old toaster. **4**

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Question 21 continues on the next page

Marks

(ii) Describe TWO technological developments needed before the production of the modern toaster could take place. **2**

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The 1950s toaster is fabricated using steel.

(iii) Explain why stainless steel is more commonly used in modern toasters. **2**

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(b) Discuss the difference between a motor and a generator and give ONE example of how each machine is used in everyday life.

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Question 21 continues on the next page

Marks

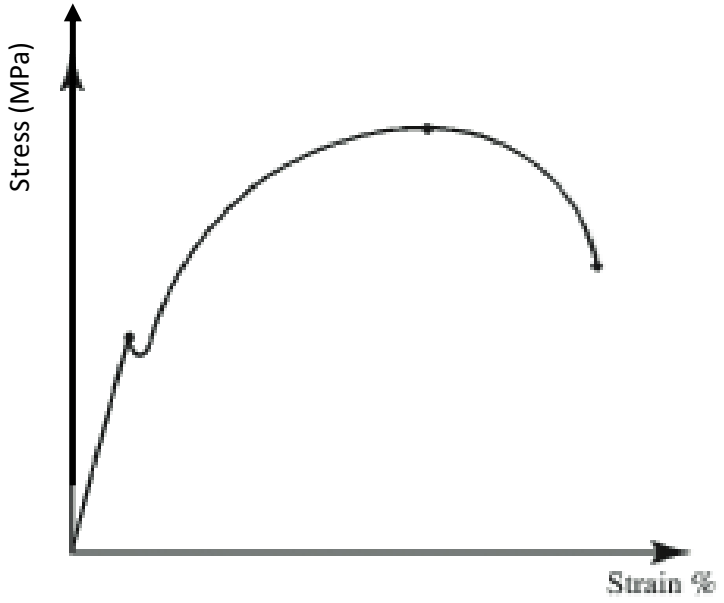
(c) A cylindrical punch, of diameter 9 mm is used to punch out the holes of a brake liner of thickness 6mm. If, during the punching operation, the compressive stress in the punch is 120 MPa, determine the force used to punch out the hole.

3

Force= ……..

(d) A stress-strain graph of low carbon steel used for the cabinet of many appliances is shown below. Clearly label on the graph, the following features:
(i) Indication of necking; (ii) Elastic zone; (iii) Plastic zone; (iv) Ultimate tensile Strength.

2



End of Question 21

Question 22 (15 marks) **Marks**

A hydraulic disc brake with a ceramic composite rotor used on a Porsche road car is shown below.



(a) List TWO advantages of disc brakes in comparison to drum brakes. **2**

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(b) Suggest TWO reasons why a ceramic composite rotor is beneficial for high performance cars. **2**

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Question 22 continues on the next page

Question 22 (continued) **Marks**

(c) *Conventional cars have disc brake rotors manufactured from grey cast iron, which is a relatively brittle material, compared to mild steel.*

(i) Discuss why *cast iron* is a desirable engineering material. **2**

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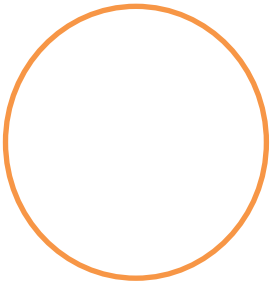
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(ii) Sketch in the circle below the microstructure of grey cast iron. Label each phase. **2**



(d) A hydraulic hoist used to raise a vehicle of mass 2.5 tonne has a Ø16 mm input cylinder and a Ø200 mm output cylinder. Calculate the input force required to raise the maximum load. **2**

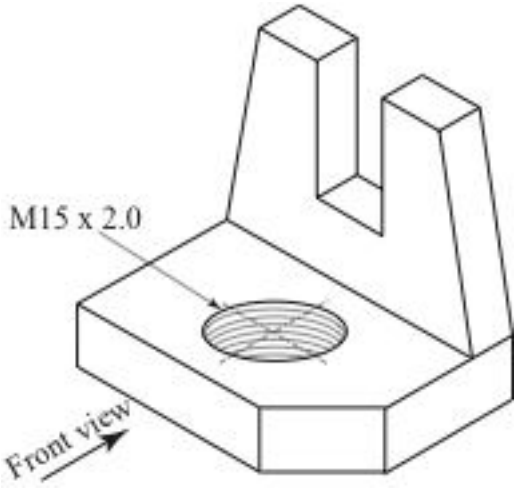
Input force = ……. N

Question 22 continues on the next page

Question 22 (continued) **Marks**

(e) A bracket used on the handle of a lawnmower is shown below in isometric projection. Using a scale of 1:1, draw the bracket in third angle orthogonal projection using AS1100 drawing standards. Include major dimensions and a half-section of the front view that passes through the centre of the threaded bolt hole.

5



End of Question 22

Question 23 – (15 marks) **Marks**

(a) Identify and explain TWO environmental issues relevant to a materials engineer.

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(b) Discuss why ethical considerations are of high importance to the biomedical engineer

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(c) Explain the importance of Pascal's Principle to modern braking systems. **2**

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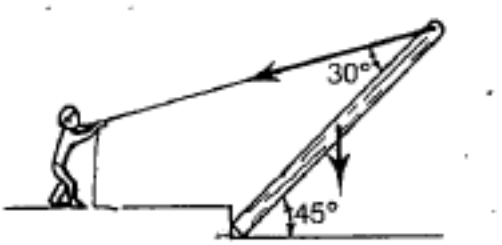
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Marks

(d) A lever is hinged at O and attached to a wire rope cable at A. Find the tension in the cable and the reaction at the hinge **8**



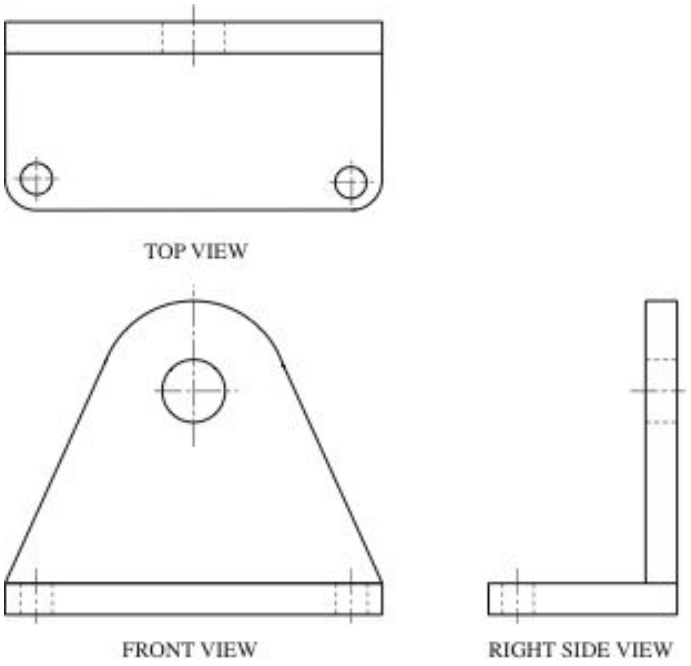
Question 23 continues on the next page

Marks

(e) A stainless steel bracket is shown in orthogonal projection.

Draw a pictorial free-hand sketch of the bracket so that the most of the detail can be seen. Take sizes directly off the orthogonal drawing.

5



End of paper

STUDENT NUMBER: ANSWERS + WORKED SOLUTIONS

STUDENT NAME: .....

TDT

GIRRAWEEN HIGH SCHOOL

MENS CONSCIA RECTI

2014

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3				X
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6		X		
7		X		
8				X
9		X		
10			X	
11		X		
12		X		
13				X
14	X			
15		X		
16			X	
17		X		
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19		X		
20		X		

Young's modulus.

Carbon steel quench at = martensite

1 A low melting point alloy used for joining electrical wires and components is known as:

(A) Acrylic
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(C) Alloy
(D) Solder

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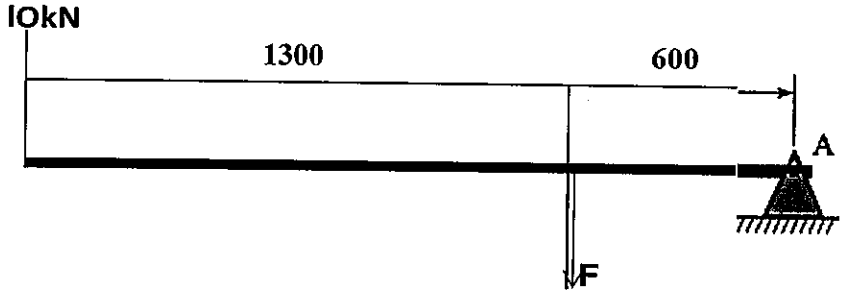
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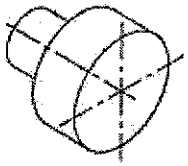
(D) 60.32 kN

$\Sigma M = 0$

$1.3M \times 10kN = F_N \times 0.6M$

$F = \frac{13\ kNM}{0.6M} = 21.6\ kN$

7. Select the correct engineering term for this part:



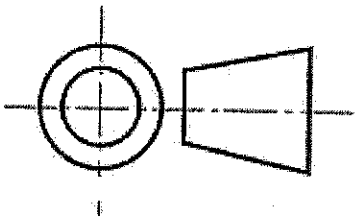
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(A) 30MPa

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$\text{Stress} = \frac{F}{A} = \frac{3\text{kN}}{20\text{mm}^2} = \frac{3\times10^3\text{N}}{20\text{mm}^2 \times \frac{1\text{m}^2}{1\times10^6\text{mm}^2}} = \frac{3\times10^3\text{N}}{20\times10^{-6}\text{m}^2}$

$\sigma = 0.15\times10^9\ \frac{\text{N}}{\text{m}^2}$

$\sigma = 0.15\times10^9\ \text{Pa}$

$\sigma = 0.15\ \text{GPa}$

$\epsilon = \frac{\text{Elongation}}{\text{Orig Length}} = \frac{3\text{mm}}{1500\text{mm}} = 2\times10^{-3}$

$E = \frac{\text{Stress}}{\text{Strain}} = \frac{0.15\times10^9\text{Pa}}{2\times10^{-3}} = 0.075\times10^{12}\text{Pa} = 75\text{GPa}$

10. What is the mechanical advantage of a machine if a 30N effort lifts a 20kg load?

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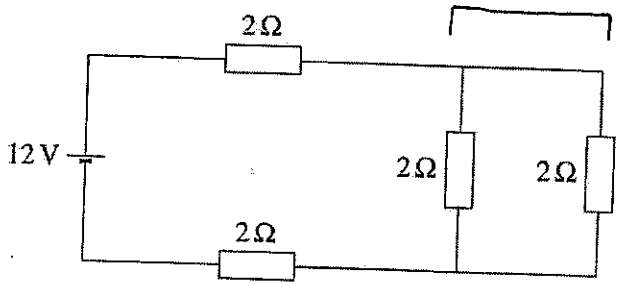
(C) 6.66

(D) 0.15

$MA = \frac{\text{Load}}{\text{Effort}} = \frac{200\text{N}}{30\text{N}} = 6.6$

11. A simple electric circuit is shown.

$R = \frac{1}{2\Omega} + \frac{1}{2}\Omega = 1\Omega$.



$R_T = 2\Omega + 2\Omega + 1\Omega$
$= 5\Omega$.

$I = \frac{V}{R_T} = \frac{12}{5} = 2.4\,A$.

What is the total current in the loaded circuit?

(A) 1.5 A

(B) 2.4 A

(C) 3.0 A

(D) 6.0 A

12. The metallic crystal structure which allows the most slip planes is:

(A) Face Centered Cubic

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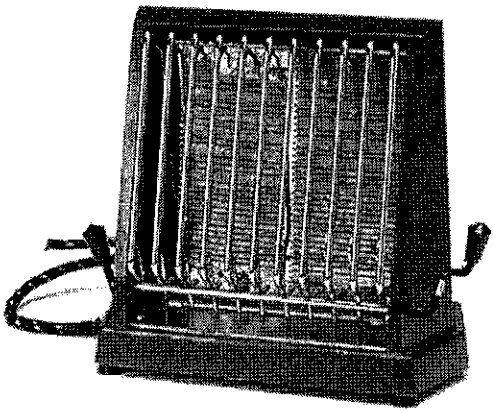
Section II

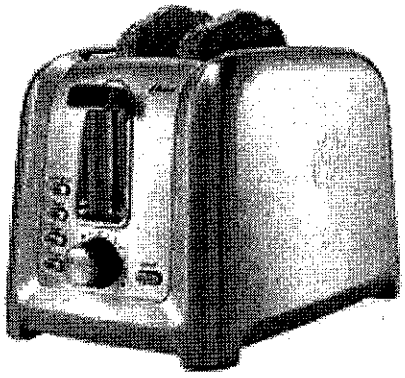
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Question 21- Engineering Products (15 marks) **Marks**

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2mks 2mks

(a) (i) Name and explain TWO significant effects on people's lives using the modern toaster in comparison to the old toaster. **4**

- enclosed cooking area.
safety - no exposed heating element, use of polymer insulation over natural rubber
control - electronic circuitry reduces weight & increase adjustability, automation of cooking process.
efficiency - heat trapped in box, option to cook more than one slice at once & heating of both sides.
weight - use of polymers reduces weight & hence price.
durability - older product is more durable and may be able to be repaired more easily, whereas the modern product will be discarded when a service failure occurs, contributing to
recyclability: older product is more easily recycled - compared of less a more limited range of materials.

Question 21 continues on the next page

corrosion resistance: Polymers & stainless steel are more corrosion resistant than mild or chrome plated steel of 1950's.

Marks

(ii) Describe TWO technological developments needed before the production of the modern toaster could take place. **2**

(1) Development of the semi-conductor paved the way for the use of miniature Integrated control circuits. that reduced cost, weight & volume of modern products.

(2) Polymer technology :— due to increased needs during WWII, synthetic polymers with insulating, strength & impact resistance and aesthetic properties replaced natural polymers. and eventually replaced heavier & more expensive manufacturing materials such as steel.

The 1950s toaster is fabricated using steel.

(iii) Explain why stainless steel is more commonly used in modern toasters. **2**

- often non-magnetic (in the case of most alloys)
- Corrosion resistance
- appearance
- strength properties = higher strength means lighter material required.
- thermal shock resistance -
- hygienic - retains less foreign matter
- fatigue & impact resistance

(b) Discuss the difference between a motor and a generator and give ONE example of how each machine is used in everyday life.

2

1) Motor - electromagnetic device changes electrical energy into KE. specifically rotating mechanical force. (1½)

Generator - converts rotating mechanical force (KE) into electrical current or electrical energy. (1½)

2) motors are used to power machines such as 3-D printers, Cordless drills and generators are used provide electrical current which can charge batteries or power the motors in the devices mentioned above. (1½)

STUDENT NUMBER/NAME: .....

Question 21 continues on the next page

Shear Stress or Compressive Stress

Marks

(c) A cylindrical punch, of diameter 9 mm is used to punch out the holes of a brake liner of thickness 6mm. If, during the punching operation, the compressive stress in the punch is 120 MPa, determine the force used to punch out the hole.

Correct use of $\sigma = \frac{F}{A}$. (1)

3

Shear Stress

$\sigma = F/A$. $\therefore F = \sigma \times A$. —(1)

$\sigma = 120 \times 10^6 Pa$.

(1) — $A =$  $= C = \pi \phi = 2\pi r = 9\pi mm$ ϕ height of Shear

surface is 6mm $\therefore 9\pi mm \times 6mm^2 = 54\pi mm^2 = 169.6\ mm^2 = 169.6 \times 10^{-6} m^2$

From (1) $F = 120 \times 10^6 Pa \times 169.6 \times 10^{-6} m^2 = 20{,}357.5\ N = 20.4\ kN$

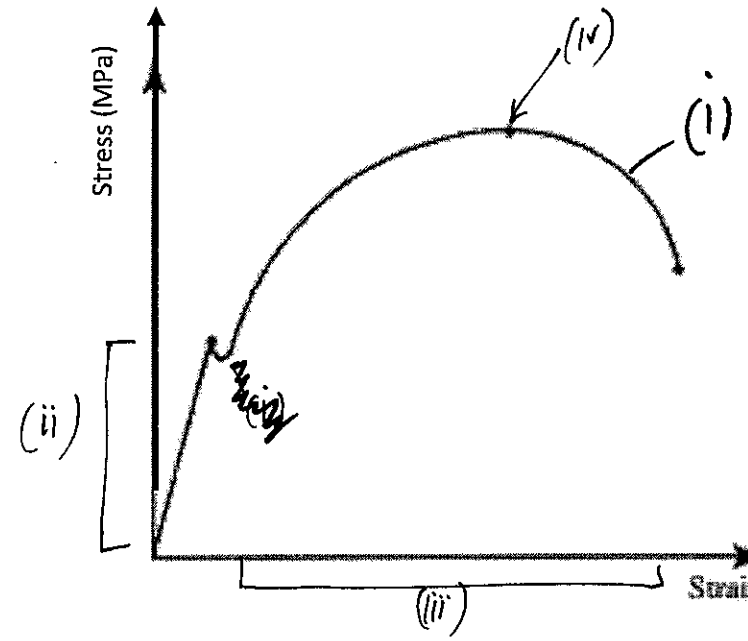
1 mk correct equation

Shear Force= ....20.4 kN.....

1 mk Correct calculating Shear surface

1 mk Correct answer.

(d) A stress-strain graph of low carbon steel used for the cabinet of many appliances is shown below. Clearly label on the graph, the following features:
(i) Indication of necking; (ii) Elastic zone; (iii) Plastic zone; (iv) Ultimate tensile Strength.



For Compressive Force.

2

$\sigma = F/A =$

$F = A \times \sigma = 120 \times 10^6 \frac{N}{m^2} \times \pi (4.5)^2 mm^2$

$= 120 \times 10^6 \frac{N}{m^2} \times 63 mm^2$

$= 120 \times 10^6 N \times 63 mm^2 \times \frac{1m^2}{1 \times 10^6 mm^2}$

$= 120 \times 63 N$

$\sigma_c = 7{,}634\ N$

Compressive Stress

$F = \sigma \times A$

$= 120 \times 10^6 \frac{N}{m^2} \times \pi (4.5 \times 10^{-3})^2 m^2$

$(1.764 \times 10^{-5})_{m^2}$

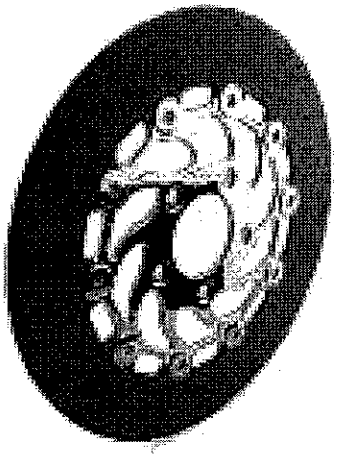
$F = 7{,}634\ N$

End of Question 21

STUDENT NUMBER/NAME: .....

Question 22 (15 marks) **Marks**

A hydraulic disc brake with a ceramic composite rotor used on a Porsche road car is shown below.



(a) List TWO advantages of disc brakes in comparison to drum brakes. **2**

- dissipate heat more easily
- resist brake fade more readily
- better wet weather properties since Centripetal force keeps them dry
- lighter weight.
- easier pad design. - less moving parts.

(b) Suggest TWO reasons why a ceramic composite rotor is beneficial for high performance cars. **2**

LOW THERMAL CONDUCTIVITY (thermal shock resistance)
HIGH MP - STABILITY AT HIGH TEMPS
comparable structural tensile strength to grey cast iron
corrosion resistance
lighter weight
less dust of non-static dust.

Question 22 continues on the next page

9/10

Question 22 (continued) **Marks**

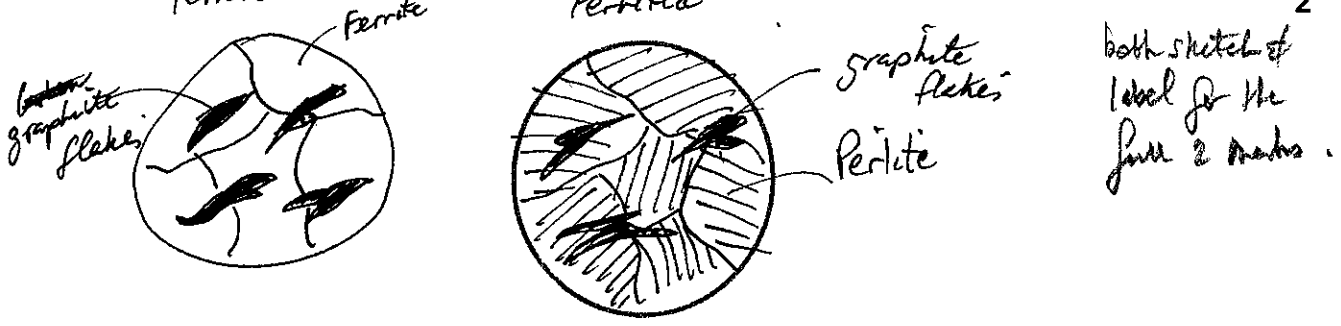
(c) *Conventional cars have disc brake rotors manufactured from grey cast iron, which is a relatively brittle material, compared to mild steel.*

(i) Discuss why *cast iron* is a desirable engineering material. **2**

low cost of manufacture. - good damping due to Graphite flakes
easy to melt, weld, cast & machine
Some corrosion resistance w.r.t. steel.
Good thermal Conductivity
Can be a good bearing surface - self lubricating

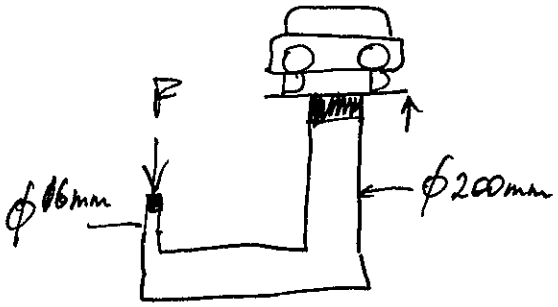
(ii) Sketch in the circle below the microstructure of grey cast iron. Label each phase. **2**

Ferritic. Pearlitic



both sketch & label for the full 2 marks.

(d) A hydraulic hoist used to raise a vehicle of mass 2.5 tonne has a Ø16 mm input cylinder and a Ø200 mm output cylinder. Calculate the input force required to raise the maximum load. **2**



$$\frac{F}{\pi(8mm)^2} = \frac{25kN}{\pi(100mm)^2}$$

$$F = \frac{25kN \times 64mm^2}{1\times10^4 mm^2} = 1600\times10^{-4}kN$$

$$= 0.16kN$$

$$= 160N$$

Students should always quote the formula they are going to use

(1) mark for correctly selecting the relationship between Pressure equivalent parts of the system

(1) 1 mark for correct calculation.

Question 22 continues on the next page

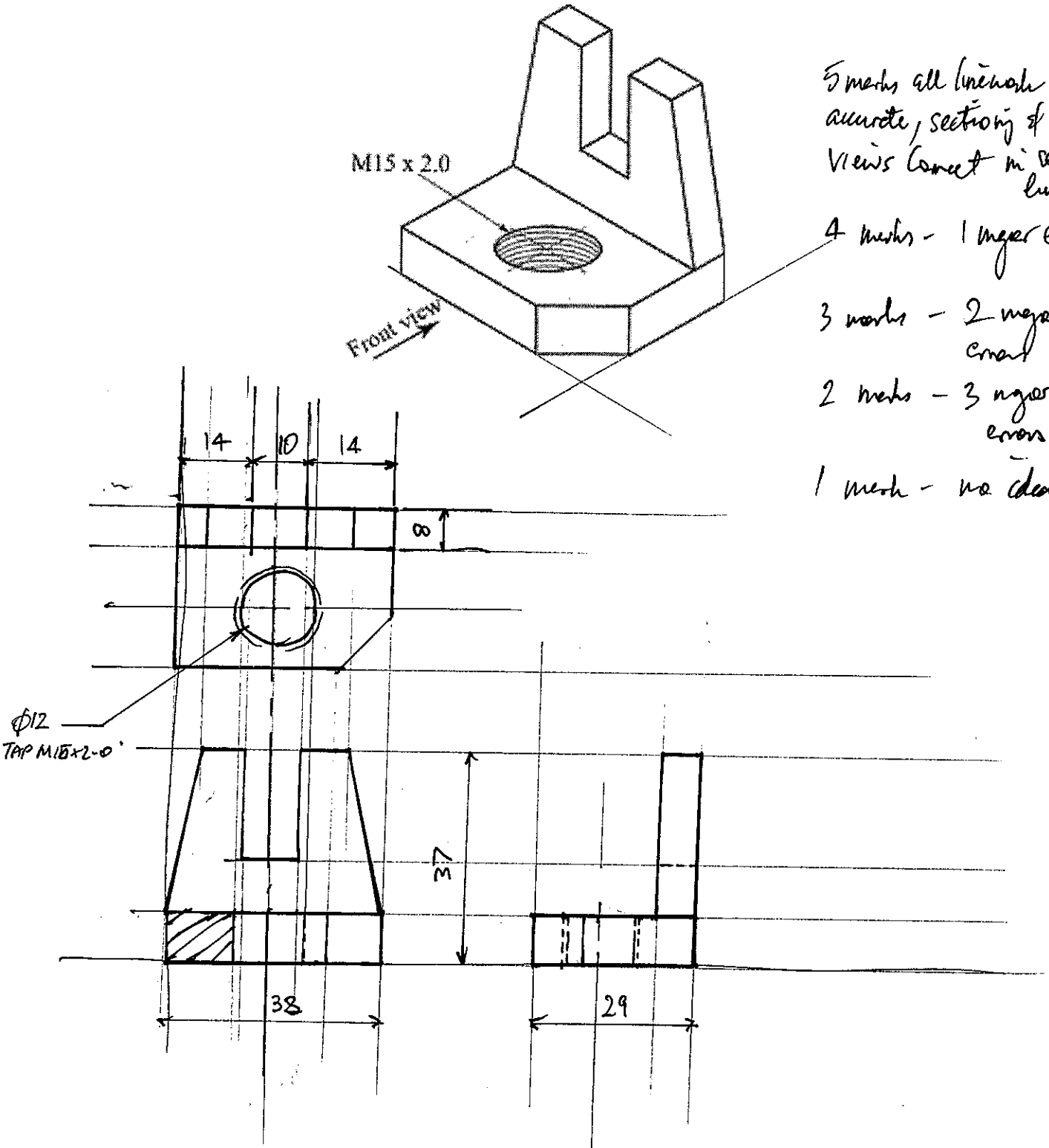
Question 22 (continued)

Marks

(e) A bracket used on the handle of a lawnmower is shown below in isometric projection.

Using a scale of 1:1, draw the bracket in third angle orthogonal projection using AS1100 drawing standards. Include major dimensions and a half-section of the front view that passes through the centre of the threaded bolt hole.

5



5 marks all linework accurate, sectioning of views correct in centre lines, dims

4 marks - 1 major error

3 marks - 2 major error

2 marks - 3 major errors.

1 mark - no idea!

End of Question 22

STUDENT NUMBER/NAME: .....

Question 23 - (15 marks)

- Reduction of waste
- Sustainable manufacturing process.
- Preserving

Marks

(a) Identify and explain TWO environmental issues relevant to a materials engineer. 3

✓ should be changed to 4

Can include
- sustainability
- recyclability / biodegradability.
- life cycle of product.
- the cost of to the environment of the manufacturing process required to produce a material. eg its affection on fauna, flora.
- reduce waste.

1 mark for identifying each area, the second for explaining how each area affects the environment.

1 mark for naming each issue/category & ½ mark for explaining the relevance of each issue.

(b) Discuss why ethical considerations are of high importance to the biomedical engineer

raise/name an issue - 1 mark - discuss & expand the issue, give an example 1 mark. 2

- Engineers are committed to improving the lives of others.
- Engineers must have a value system by which they can balance the interests of society, past & present
- The work of bio-med. engineers directly affects the lives of the people they are assisting.
- Others rely on the engineer to make decisions based on skill and understanding which they do not possess - there is a trust relationship

(c) Explain the importance of Pascal's Principle to modern braking systems. 2

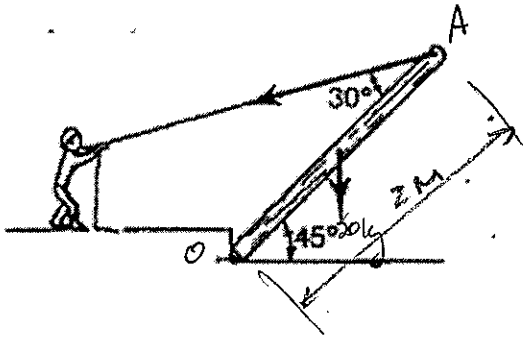
Pascal's principle: "Pressure applied to a liquid in a confined space is transmitted equally throughout the liquid and is exerted normal to the surface containers walls."

Answers could include. reduction in friction, flexibility in force transfer & simple application of mechanical advantage eg varying piston diameters.

STUDENT NUMBER/NAME: .....

Marks

(d) A lever is hinged at O and attached to a wire rope cable at A. Find the tension in the cable and the reaction at the hinge **8**



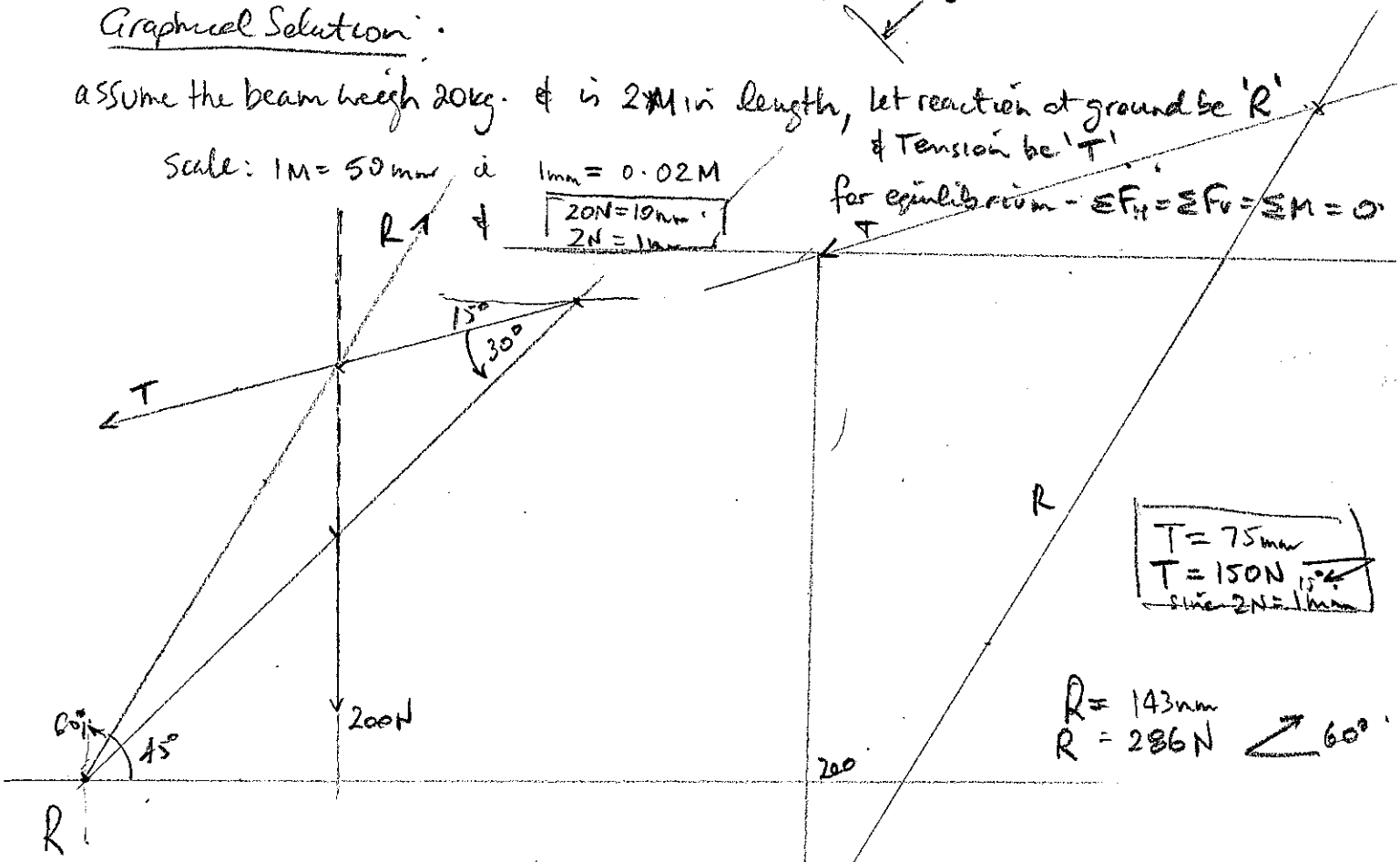
Graphical Solution:

assume the beam weigh 20kg. & is 2M in length, let reaction at ground be 'R' & Tension be 'T'

Scale: 1M = 50mm i.e. 1mm = 0.02M

20N = 10mm
2N = 1mm

for equilibrium - $\Sigma F_H = \Sigma F_V = \Sigma M = 0$



T = 75mm
T = 150N
since 2N = 1mm

R = 143mm
R = 286N ∠ 60°

Note: ○ answer must show a scale ①
○ must state assumptions: weight, Force labels such as R, T.
○ must state magnitude, sense & direction. ①

Graphical solution: must show f.b.d. accurate. ②
" " " Correct. Force Polygon with resultant ②

Total 8.

Correct answer/working: ①

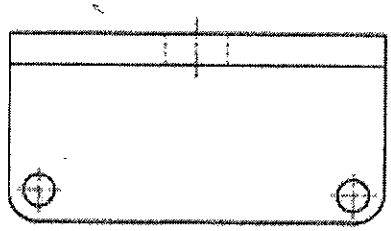
Mks	
1	stating conventions
1	FBD
1	∠ of R
2	Vector Polygon
1½	T + ∠
1½	R + ∠

Question 23 continues on the next page

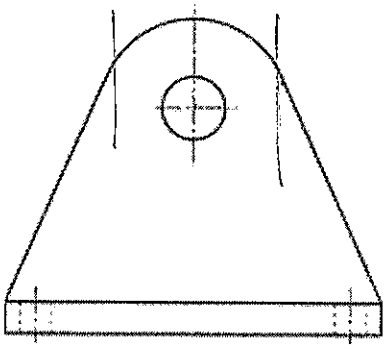
(e) A stainless steel bracket is shown in orthogonal projection. **Marks**

Draw a pictorial free-hand sketch of the bracket so that the most of the detail can be seen. Take sizes directly off the orthogonal drawing.

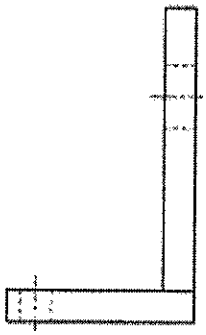
5



TOP VIEW

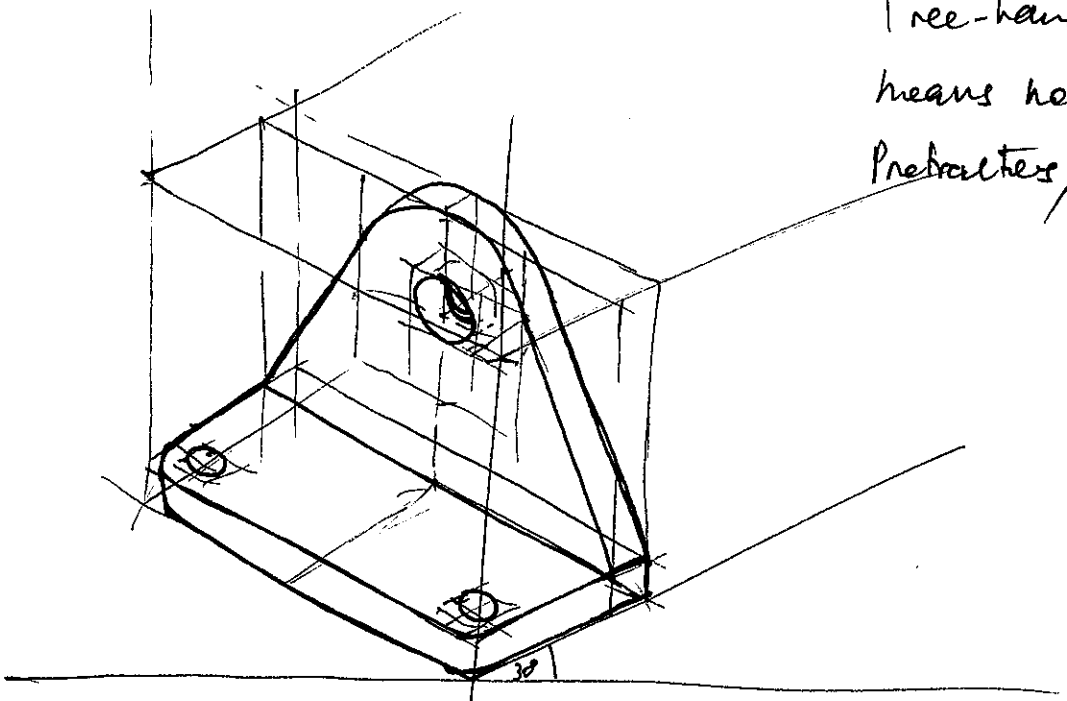


FRONT VIEW



RIGHT SIDE VIEW

Free-hand means no rulers / Protractors, etc.



4 correct proportions, linework - most detailed.

3 One major error.

2 2 major errors

1 - most not completed

End of paper