OPEN QUESTIONS

Part 1 –*part manufacture*

Tooling

a) Describe briefly what is meant with “universal” tooling and what is the opposite of “universal” tooling?
b) Is it possible to create parts with two soft tools only? Explain your answer.
c) Why is a set of matching dies much more expensive than a tooling set for rubber forming?
d) What is the relation between the costs of tooling and the product series?

Bending

a) Describe briefly the air bending principle and the rubber backed bending principle.
b) What are the advantages of the two principles (2 advantages for each)?
c) In bending you need to compensate for spring back. Explain this statement.
d) Does the spring back increase or decrease when the sheet thickness is reduced? Explain your answer.

Forming Limit Diagram (FLD)

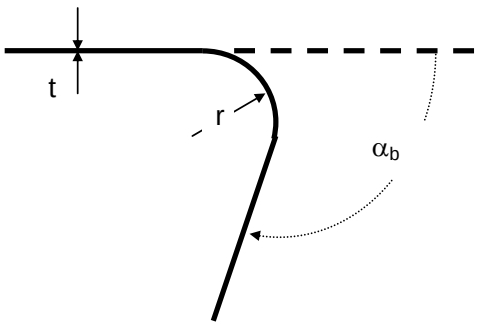
A forming limit diagram is a specific diagram used during sheet metal forming.

a) Make a sketch of a FLD and explain your drawing (what is on the axes? What is the diagram representing?).
b) What strains are represented in the FLD: plastic strains, elastic strains or both? Explain your answer.

Spring back

Spring back is a phenomenon that occurs e.g. during bending (See sketch)

a) What happens with the bend angle (α_b) due to spring back: Is the angle after spring back larger or smaller? Explain.
b) What about the radius: Does the radius increase or decrease? Explain.
c) Is there a relationship between the radius and the angle? If yes, which one?



Bending

During bending the cross section is loaded beyond its yield limit.

a) Make sketches of the stress distribution and the stain distribution over the cross section (over the thickness).
b) In the cross section during bending you will have a so-called “neutral axis”. What is a neutral axis?

c) During air-bending or V-die bending the radius is not constant in the bend zone. Explain this.
d) During roll bending the radius is more or less constant in the bend zone. What is the difference with the other types of bending (like air bending and V-die bending)?

Machining, Casting, Forming
For the manufacture of parts, several main manufacturing processes are available, like Machining, Casting and Forming.
a) Describe for each of these main groups, how the part gets its shape/geometry.
b) Mention for each group at least three processes that belongs to that group.
c) Mention for each group at least two limitations.

Deep drawing
The tooling for deep drawing processes consists of three elements.
a) Name the three elements and tell whether each element is product related or not.
b) In deep drawing the flange is transformed into the cup wall. Make a sketch of the loads acting on the elements of the tooling set.
c) The drawing action (draw-in of the flange) can be improved by reducing the friction. Where and how?

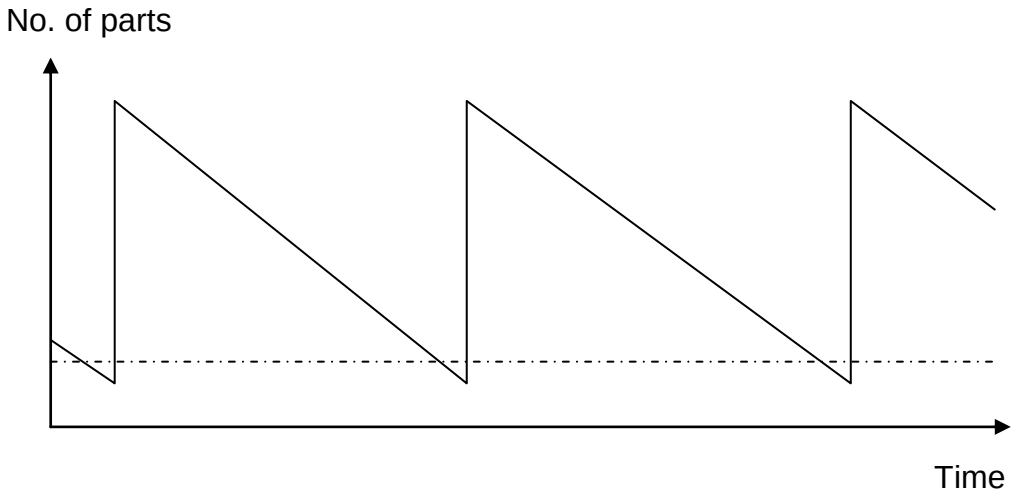
Superplastic forming
Superplastic forming is applicable only to a limited number of metal alloys.
a) Give a brief description of the superplastic deformation behavior.
b) Two requirements for superplastic forming are stable grains and high forming temperature. Explain how these requirements often contradict.
c) Another requirement results in a small strain rate. Which requirement is that?
d) Why is the small strain rate a disadvantage too?

Rubber forming is the most frequently used sheet metal forming process in the industry.
a. Why?
Rubber forming is performed by applying two die principles: male and female dies.
b. Compare these two principles and give for each an advantage, a disadvantage and an example product.
c. Is it possible to rubber form a sheet with local variations in thickness? Explain your answer.

Bulk forming processes like **forging and extrusion** are performed at high temperatures.
a. Why? Explain your answer by using a micro structural model.
b. During forging often lubrication is used between the dies and the product. Why?

Part 2 – *assembly & joining*

Batches
a) Give a brief description of a “Batch”.
b) The figure below presents the number of parts in stock as function of time. Give a brief description of the features in this plot (peaks, slope, dotted line).
c) What is the explanation that the lower peaks are below the dotted line?



Riveting

a) Describe two different rivet types and the installation methods for those rivets.
b) Rivet holes are preferred locations for crack initiation. Describe two principles that can be used to retard crack initiation.
c) Give a qualitative comparison between a riveted joint with one rivet row and a joint with two rivet rows.

Line production is the leading production principle in the aircraft industry.

a) Give a brief description of the following entities: “station”, “learning curve”, “delivery interval”
b) What is the main reason to increase the number of shifts in the production? Explain your answer.
c) What, from a workers’ perspective, are the advantages of line production over mass production (as used in the automotive industry)?
d) What are the key features of a “station”?

Reasons for Assembly

Some reasons for assembly are:

Different materials; different thicknesses, size, politics, economics, accessibility, maintainability.

Give for each item a brief explanation why that item could be a reason for assembly.

Adhesive bonding

Adhesive bonding is one of the joining methods used in the aerospace industry.

a) Mention at least 2 advantages and 2 disadvantages of adhesive bonding.
b) The quality of adhesive bonding is highly dependent on the pretreatment of the adherents (parts to be bonded). Why are these pretreatments so elaborate? Mention at least one of the reasons and explain your answer.
c) The adhesive bonded joints transfer the load by shear forces. The highest stresses occur at the edges of the bond. Explain this.

Autoclave process

The autoclave is a special tool/machine used for the curing of adhesives/composites.

a) What are the strong points of the autoclave curing process (mention at least two)
b) What is the biggest disadvantage of autoclave curing?
c) What is required for materials that are cured outside an autoclave, e.g. in an oven?

Riveted joints

a) Riveted joints may encounter several failure modes. Which ones?
b) If the riveted joint fails by net section failure, what measures could be taken to increase the strength of the riveted joint.
c) What is the effect of replacing aluminum solid rivets by titanium hi-locks?

Batches

a) A batch is a group of parts which is handled and processed as one group through the manufacturing and assembly process. What is wrong in this definition? Explain.
b) In the aircraft industry the batch is usually about 20-60. Mention at least two circumstances that this number should be increased.
c) When is decided that a new batch should be made? Explain your answer briefly.

Bath tub curve

The load transfer in adhesive bonding is described with the “bath-tub” curve.

a) Give a brief description (or sketch) of the ‘bath-tub”.
b) Give an explanation of the bath-tub curve (how does it occur?)
c) What happens with the force in the joint when the overlap length increases? Sketch the force as function of the overlap length.

Parts are made in **batches**.

a. Does the part size have an influence on the batch size? Explain your answer.
b. What happens with the batch size when the number of aircraft sold increases? Explain your answer.
c. Mention at least two **more** production/part variables that influence the batch size and explain whether the batch size increases or decreases.
d. Is JIT (Just In Time) production a possible solution for aircraft production? Explain your answer.

The figure below show a schematic picture of a **riveted single lap joint**.

a. Explain how the load is transferred from one sheet into the other.
b. Describe at least two possible failure modes.
c. Give a simplified formula for one failure mode. Explain the formula and its parameters.

The shear stress distribution of a **bonded single lap joint** can be defined as a “bath tub curve”.

a. Make a sketch of a “bath tub curve” and indicate the parameters that are presented in this curve
b. Give an explanation of the occurrence of the bath tub curve in bonded joints.
c. What happens with the curve when the thickness of the sheets in the overlap are increased? Explain your answer.

You are asked to **assemble** a wing section, e.g. a horizontal tail plane.

a. Make a sketch of the assembly jig you would design for this section.
b. Explain how you take care of the accuracy of section and how you attach the parts to the jig before joining them.
c. Mention at least 4 functions/features that should be incorporated in your assembly jig.

The manufacture of aircraft can be divided in “**part manufacture” and “line production**”

a. Mention at least three differences between these two ways of manufacturing
b. In line production we use so-called stations. What are the key features of a station?
c. What are the possible adaptations in the line production for a decrease of the delivery interval? (mention and explain two changes).

Assembly

a. In the structural breakdown of an aircraft one can distinguish mounting divisions and manufacturing divisions. Give a brief description of both types of divisions.
b. What joining methods are suitable for mounting divisions? Why?
c. What joining methods are suitable for manufacturing divisions? Why?
d. Mention at least 2 structural features which are ideal to create a manufacturing or mounting division.

Assembly of aircraft.

a. Mention four different reasons why an aircraft has to be assembled.
b. The structural breakdown of an aircraft results in manufacturing and mounting divisions. Mention one typical example for each and explain why this is a manufacturing or mounting division?
c. "Assembly adds weight to an aircraft". Which feature(s) in the joint contribute(s) the most to the weight increase?

Part 3 – *Miscellaneous topics*

Lean Manufacturing

a) Mention and describe briefly the two most important features or key words related to lean manufacturing.
b) Give a brief description of the Just In-Time (JIT) principle.

Non-Destructive Testing

a) Is the following statement true or false; explain your answer: "Non-destructive testing becomes more important when the aircraft industry applies more fiber reinforced polymers in aircraft structures".
b) What will be the most important defects in fiber reinforced polymers? Explain your answer.

Trinity concept

The trinity concept describes the interaction between the type of material, the manufacturing principle and the shape or design.

a) What are three manufacturing options for metal sheet?
b) What are two manufacturing options for 5 cm wide UD-prepreg tape (continuous fibers)?
c) What material and manufacturing process fits to long thin-walled tubes? Mention at least one combination.

Lean Manufacturing

a) Give in your own words a brief definition of the principle of Lean Manufacturing.
b) Lean Manufacturing distinguishes several types of waste. Mention three types a explain briefly why these are regarded as "waste".

Product features are used to select the most appropriate manufacturing process.

a. Mention at least three product features that can be used for the selection of the best (sheet metal) forming process.
b. Select one feature and explain how this can be used during selection and give a practical example.

Assume you have to make a front spar for the wing of an aircraft.

a. What manufacturing process would you use in case of aluminium and what process in case of a composite spar? Explain your answer.
b. Explain if and how the size of the spar and the product series influence on your choices made at Q21a. (in other words: would your choices change when the size or the product series changes significantly)?
c. What joining method would you select to join an aluminium skin to the aluminium spar? Explain your answer.
d. How would you control the quality of the joints you made in Q21c? Describe your quality control process.
e. Make a sketch of the assembly jig you will use to assemble the spar and other elements to a complete wing (box). Indicate the important features of the jig.

(NB. If you could not answer Q21a or Q21c, make an assumption to answer Q21b resp. Q21d)

MULTIPLE CHOICE QUESTIONS

Part 1 – *Part manufacture*

Superplastic forming
Two major disadvantages in superplastic forming are “cavitation” and “thinning”. What statement is true about these disadvantages? (one answer)
a) Cavitation and thinning are two phenomena that occur at the same time
b) Excessive cavitation will render the materials or part useless (should be scrapped)
c) Excessive thinning will render the materials or part useless (should be scrapped)
d) Thinning can be counteracted easily, cavitation cannot be counteracted.

Rubber forming
Which of the following statements about rubber forming is true (one answer)?
a) The rubber forming process has many variables like the pressure, the lubrication, the working temperature
b) Rubber forming is ideal for so-called flanged parts: flat web plates with curved flanges at the periphery
c) Rubber forming is ideal for so-called deep drawing shapes; the height/diameter ratio can easily exceed 1.5
d) The biggest disadvantage is the long cycle-time which cannot be overcome by any measure.

Heat treatment
A heat treatment may have the following impact on metal sheet:
a) The yield stress is increased and the ductility is reduced
b) The ductility is increased and the formability is increased
c) The sheet shows warpage (distortions) and becomes more brittle
d) The yield stress is reduced and the stiffness is increased.

Which one of these alternatives is not true?

Blank holder
Which of the following statements about the blank holder as used during deep drawing is false?
a) The function of the blank holder is to prevent wrinkling during deep drawing
b) In a given setting (size, sheet thickness, etc), the blank holder force has an optimum
c) When the blank holder force is increased the punch force can be reduced

d) Lubrication has hardly any effect on the blank holder force.

Deep drawing
Successful deep drawing (drawing a full cup) is possible when:
a) The stretching force is larger than the drawing force
b) The stretching force is smaller than the drawing force
c) The stretching force and drawing force have the same value
d) There is no link with the stretching or the drawing force.

Explosive forming
Explosive forming is a process which:
a) Is able to form large and thick walled shells
b) Can be performed anywhere in the world
c) Requires dedicated people and tooling
d) Is applicable to medium size (O(1000)) product series
Which answer(s) is/are false?

Superplastic forming
The “super” in Superplastic forming is related to:
a) The very large deformations that can be achieved in one process cycle
b) The high speed during the process, i.e. the very high deformation rate
c) The high temperature at which the deformation takes place
d) Nothing of these three topics.
One answer is true; which one?

Spring back
The following statements about spring back are presented:
1. In-plane spring back is regarded as non-relevant, but out-of-plane spring back is regarded as highly relevant for forming operations
2. In-plane spring back is dominated by the E-modulus and thickness; the out-of-plane spring back by the curvature, thickness, yield stress and E-modulus

Which of the statements is/are true?
a) Both statements are true
b) Statement 1 is true; statement 2 is false
c) Statement 1 is false; statement 2 is true
d) Both statements are false

Forming of FRTP
What statement about processing Fiber Reinforced ThermoPlastics (FRTP) is false?
a) With adequate heat laminates of FRTP can be press formed like metal sheets
b) Resin injection processes cannot be applied to FRTP due to its high viscosity
c) Filament winding of FRTP is possible when the yarns include the polymer
d) For the hand lay-up of FRTP the prepregs have to be cut using thermal knives.

Some metal alloys can be **heat treated**, inducing a change in the microstructure. What is a disadvantage of a heat treatment?
a. The metal alloy becomes weaker and softer
b. The E-modulus of the metal alloy may have a lower value
c. The heat treatment can be performed in special factories only
d. The heat treatment induces extra costs and time to the product

Spring back and residual or internal stresses are both related to elastic deformations. What statement is true?
a. The residual stress increases when the spring back angle increases
b. Residual stresses are one way to express the spring back of the material

c. Spring back and residual stress are complementary: if one increases, the other decreases.
d. For one material, the ratio of the values for spring back and residual stresses are constant

There are multiple **forming principles**. Which of the following statements is not true?
a. Plastic deformation is based on movements of small defects in the crystal lattice, so-called dislocations.
b. Plastic deformation and superplastic deformations are based on the same principle, although the temperature is different
c. Thermoplastic composites with continuous fibres can be deformed into 3D shapes by intra-ply and inter-ply shear deformations
d. The deformation of thermoplastic composites with short fibres is dominated by the flow of the polymer

Explosive forming is a forming process (one answer):
a. Which is only applicable to small product series
b. Which can be applied on both metal sheets as on composite laminates
c. Which results in very high strain rates and a very short cycle time
d. Which results in very high strains (large complexity)
One answer is correct.

What statement about **impregnation** is false?
a. Impregnation is the mixing of the fibres and the resin
b. In a prepreg the fibres and resin are already mixed in the proper ratio
c. Impregnation can be performed before and after shaping of the fibre architectures
d. The polymer used for impregnation should have a high viscosity

What are the advantages of **thermoplastic matrix materials** over thermoset materials? Thermoplastics..
a. … are tough, have high impact resistance, have high application temperature
b. … have high viscosity, reversible thermal processing, high impact resistant
c. … are fit for RTM processes, have small residual stresses, and high application temperature
d. … are tough, don't need special storage requirements, are fit for RTM processes
(which statement is correct?)

Which **casting** process uses a model to create the casting die?
a. Die casting
b. Injection Moulding
c. Investment casting
d. None of the previous answers is correct

Which of the following processes is a **separation** process and not a machining process?
a. Punching
b. Water jet cutting
c. Drilling
d. Laser cutting

Which of the following statements about **machining** is false?
a. Machining of composites is more difficult than machining of metals because of the abrasive fibres and the layered structure of composites
b. The flank angle in machining is a small angle; it is to prevent wear and friction due to the spring back of the work piece material

c. When the rake angle is smaller than 0 degrees, no chip removal is possible
d. Lubrication during machining has 3 functions: cooling, chip removal and reducing wear

Forging is a forming process performed at high temperatures. What statement is true?
a. Forging and casting, both high temperature processes, apply the same deformation mechanisms
b. The high temperature in forging is applied to increase the yield strength and reduce the failure strain
c. The high temperature increases the formability of the material, by reducing the forces and increasing the allowable deformations
d. Forging is a high temperature forming process applied on bulk as well as sheet materials.

Part 2 – *Assembly & joining methods*

Assembly
Reasons for assembly are (one answer):
a) Use of different materials, risk share, accessibility, rigid-flexible joints, integral structures,
b) Size of the structure, use of different materials, risk share, work share, accessibility
c) Size of the structure, work share, accessibility, rigid-flexible joints, political stability
d) Risk share, work share, accessibility, ease of assembly, integral structures, level of education

Adhesive bonding (process)
Which of the following statements is false? (one answer)
a) In the adhesive bonding process the surface pretreatment is the most critical step
b) An adhesive bond should be designed to transfer shear forces, no tensile forces
c) In the adhesive bonding process the curing process is the most critical step
d) The different layers in an adhesive bond act like a chain: the weakest link determines its' strength

Batches
Which of the following statements about batch production is true?
a) The batch size is always the same for specific part
b) Batches are used in part manufacture as well as in line production
c) The larger the batches, the larger the required storage space
d) The batch size is related to the delivery interval only

Adhesive bonding
What is the right order for the production of adhesive bonded joints:
a) Cleaning – priming – anodizing –pickling – applying adhesive – curing – trimming
b) Priming - cleaning – pickling– anodizing– applying adhesive – trimming - curing
c) Cleaning – pickling – anodizing - priming – applying adhesive – curing – trimming
d) Priming - cleaning – anodizing –pickling – trimming - applying adhesive – curing

Pre-deformation of lug holes.
Holes in lugs for highly loaded joints are often pre-deformed by hole expansion. Why?
a) Because pre-stressed material is stronger than non-stressed material.
b) Because pre-deformation introduces favorable internal stresses to retard crack growth
c) Because pre-deformation introduces favorable internal stresses to postpone crack initiation
d) Because the bolts that are use in those joints have a larger diameter than the hole diameter.

Integral part and an assembled sub-structure

The following statements are about integral and an assembled substructure:

1. Integral parts are advantageous with respect to manufacturing costs but are a disadvantage with respect to performance
2. An assembled substructure has a disadvantage with respect to tooling costs but has an advantage with respect to damage growth.

Which of the statements is/are true?

a) Both statements are true
b) Statement 1 is true; statement 2 is false
c) Statement 1 is false; statement 2 is true
d) Both statements are false

Different joining techniques

There are a number of different joining techniques. Which statement(s) is/are correct?

a) Bonding and welding provide air- and liquid tight joints
b) Stress concentrations are much less in bonded and bolted joints
c) Welding cannot join different metals, but it can join different alloys of the same metal
d) Both riveting and bolting are used for joints loaded in tension

Bolts can be loaded in tension and in shear. For tension fittings bolts are often preloaded. Why? (select the best answer)

a. Preloading induces significant friction between the components which is used to transfer (part of) the load
b. Due to the preloading the tension fittings are in compression and the bolt is in tension
c. Preloading is applied to increase the fatigue life of the bolt
d. Due to the preloading the tension fittings are always in contact with each other

Welding is not a favorable joining method for aircraft structures. Why not? (select the best answer)

a. By welding large integral sections are created which have no crack stopping capability
b. By welding the microstructure is dramatically changes, resulting in significant changes in properties
c. Welded joints result in fatigue sensitive structures which are not useful for aircraft structures
d. Welded joints can only be applied for joints between similar materials.

What are reasons for the application of **manufacturing divisions**? (one answer)

a. Equally sized work packages; accessibility of the section; easy transport of sections
b. Account for size of machinery; ability to assemble/disassemble; division between single/double curves
c. Allow move-ability; ability to connect dissimilar materials; creation of cheap joints
d. Create hinging functionality; result of work share; between stiff and flexible sections

What is meant with the "**learning curve**"? (one answer)

a. The curve that shows the decrease in man hours with increasing serial number
b. The curve that shows the level of skills of the work force as function of time
c. The curve that shows the routine of an individual worker as function of time
d. The curve that shows the amount of training of the work force over time

Replacing a solid **rivet** (aluminium) by a hi-lock rivet (titanium),

a. Increases the bearing strength of the joint and may result in a reduced rivet pitch
b. Increases the shear strength of the rivet and may result in a reduced rivet pitch
c. Increases the bearing strength of the joint and may allow for increasing the rivet pitch
d. Increases the shear strength of the rivet and may allow for increasing the rivet pitch

Select the correct answer.

What statement about hole-to-hole **assembly** is not correct?
a. Hole-to-hole assembly for smaller parts is more difficult than for larger parts
b. Hole-to-hole assembly can also be referred to as “meccano”-type assembly
c. Large benefit of hole-to-hole assembly is the elimination of drilling chips (etc.) at the assembly site
d. One requirement to implement hole-to-hole assembly is the use of conditioned workshops

What is the most important feature of an **assembly jig**?
a. It’s size (dimensions)
b. The required floor area
c. It’s stiffness
d. It’s price

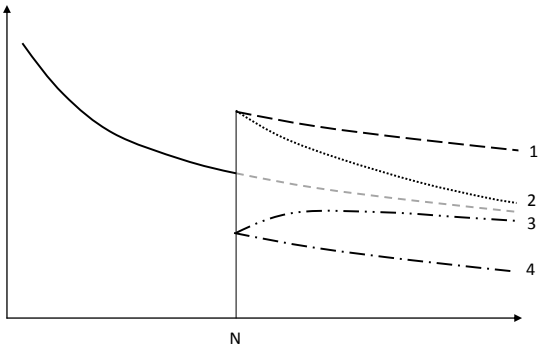
Which statement about **welding** in aircraft manufacturing is not correct?
a. Welding is not so popular because it disrupts well prepared microstructures
b. Welding is usually an expensive method, due to the expensive equipment needed
c. Welded joints have a negative impact on the damage tolerance behaviour of a structure
d. Welded joints have a local thickness increase to compensate for lower strength at the weld

The shear stress distribution of an **adhesive bonded joint** resembles a “bath-tub” curve. What statement about an adhesively bonded joint is true?
a. The total shear force of a bonded joint increase when the overlap decreases.
b. The maximum stress in the joint is the maximum shear force divided by the overlap area
c. The shear stress at the edges is higher because of larger deformations in the adhesive
d. There is a fixed ratio between the maximum and average shear stress in the adhesive bond

The following statements are about **manufacturing and mounting divisions**. Which is false?
a. Manufacturing divisions result from structural breakdown and facilitate the work share
b. Manufacturing divisions manufacture parts, mounting divisions assemble the parts
c. Separations in the structure to easy assembly are called manufacturing divisions
d. Divisions that are aiming at an easy operation of aircraft are called mounting divisions

Which of the following statements about “part manufacture” or “the **assembly line**” is true?
a. In part manufacture the workers “travel along” with a batch or parts until they are completed
b. The production speed of the part manufacture and assembly line are constant
c. In the assembly line the workers “travel along” with an assembly until its finished
d. The warehouse (the stocks of parts) divides the part manufacture and the assembly lines

When a modification is implemented in the assembly of aircraft number N, the **learning curve** changes according to line (see figure):
a. Line 1
b. Line 2
c. Line 3
d. Line 4



About **riveted and bolted joints** the following statements are formulated:
a. For the preloading of a bolted joint, the stiffness of the bolt should be much larger than the stiffness of the flange material
b. Load transfer by friction between the components is one of the methods used in bolting of composite structures
c. Bolted and riveted joints become more effective when more and more rows are added to the joint
d. Solid rivets are very effective in joining metal sheets, but are not allowed for the joining of composite laminates.

Which one is true?

Part 3 – *Miscellaneous topics*

Non Destructive Inspection (NDI) techniques

Which of the following statements is false? (one answer)
a) NDI techniques are used for flaw detection during production and in service
b) Some NDI techniques are capable of detecting flaws inside the material, others to detect flaws at the surface
c) The Dye penetrant technique is capable of detecting flaws inside the materials (like pores, inclusions)
d) The X-ray technique is based on detecting differences in density and thereby not capable to detect delaminations

Safety

Which statement about damage and safety issues is correct?
a) The safe life principle is used when no inspection is possible
b) The fail safe principle is applied when the assembly consists of multiple parts
c) The damage tolerance principle includes that any damage can be tolerated
d) None of these statements is true.

Non-destructive testing (NDT)

Which of the following statements about NDT is not true?
a) NDT methods should not hamper the functionality and quality of the tested part
b) Typical NDT methods for surface damages are: dye penetrant and Eddy Current
c) Typical NDT methods to detect damages in the material are: X-ray and Ultrasonic
d) For a good NDT-research one surface or one sub-surface technique is sufficient

Value stream mapping; 5S; JIT; Load leveling

Which of the following descriptions of Lean Manufacturing tools is correct?
a) In value stream mapping all activities in the manufacturing process are recorded and valued
b) In load leveling the physical burden (ARBO) for the employees is equalized
c) Just in Time (JIT) means that there is no waiting time for the machine and its operator
d) 5S is a LM-tool related to 5 different (monitoring) systems used in manufacturing processes.

What is the best definition for the entity “waste” as used in **Lean Manufacturing**?
a. Waste are all those materials, scrap and leftovers that have to be removed after production
b. Waste are all those activities that support the production but does not add anything to the product.

c. Waste are all those activities that do not contribute to the value of the product
d. Waste are all those activities that are not favored by the stakeholders of the company

What is the **Break Even Point** of an aircraft program?
a. It is the aircraft number at which the total revenues equals the total costs
b. It is the point in time where the total revenues equals the total investments
c. It is the point in time where the profits become equal to the total costs
d. It is the aircraft for which the costs and revenues are equal

Non Destructive Testing (NDT) techniques. Which of the following statements is false?
a. NDT techniques are used for flaw detection during production and in service
b. Some NDT techniques are capable of detecting flaws inside the material, others to detect flaws at the surface
c. The Dye penetrant technique is capable of detecting flaws at the surface, like cracks
d. The X-ray technique is based on detecting differences in density and thereby not capable to detect voids or inclusions.

The manufacture of a composite component consists of a number of activities. Which of them is not “value adding” according to the definitions of **Lean Manufacturing**?
a. Tape laying and cutting
b. Autoclave process
c. Trimming by machining
d. Quality control by Non-Destructive Testing (NDT)

Several statements are given about topics related to **sustainability**. Which one is correct?
a. A Life Cycle Analysis (LCA) evaluates the complete flight cycle of an aircraft
b. A Life Cycle Analysis is a method to calculate the total manufacturing & operational costs of a component
c. The cradle to cradle concept aims at the reuse of “end-of-life” products for their original purposes
d. Sustainability is the concept that tries to avoid excessive use of natural resources

About the relationship between the **product series** and process features, the following statement are made: which statement is false?
a. If a process requires more tooling, matching and alignment, the optimum product series increases
b. The optimum product series is not related to product size, used material or product tolerances
c. There is a direct relation between the process’ cycle time and the product series
d. The optimum product series for rubber forming is smaller than for deep drawing

Which of the following examples does not represent (cannot be linked to) the **Trinity Concept**?
a. Drilling and turning are typical machining processes
b. A lot of aluminium and steel alloys can be casted
c. Bronze tower bells are made by sand casting
d. Stretch forming is a typical process to make smooth double curved shells.