Surname, Name:

PhD Qualifier Exam – Manufacturing – Spring 2025

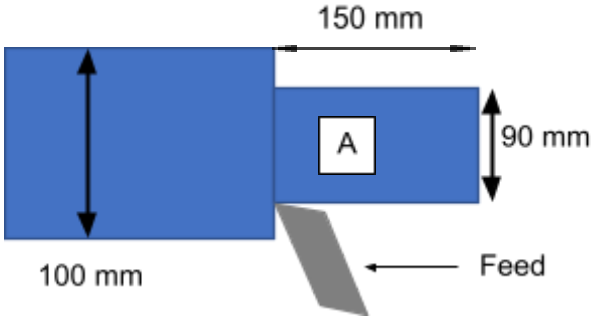
(You should answer 5 questions out of the following 6 questions. Please strikethrough the question which you did not attempt). Each question worths 20 points

Question 1

A rectangular workpiece has the following original dimensions: 2a = 100 mm, h = 30 mm and width = 20 mm. The metal has a strength coefficient of 180 MPa and a strain-hardening exponent of 0.2. It is being forged in plane strain with μ = 0.2. Calculate the force required for the height to be reduced by 20%.

Question 2

For the turning operation shown, the aim is decreasing the diameter of section A from 100 mm to 90 mm, where the length of the section is **150 mm.**



a. What is the depth of cut (mm)? **(3 pts)**
b. What is the cutting speed (m/min) if the spindle rotates at 500 rpm? **(4 pts)**
c. Calculate the feed per revolution (mm/rev) if the feed velocity is 200 mm/min. **(4 pts)**
d. Determine the material removal rate in mm^3/min **(4 pts)**
e. Determine the cycle time if the allowable depth of cut was 0.5 mm, where the other cutting parameters are as given in b) and c) **(5 pts)**

Question 3

With respect to forging.

(a) Explain the reasons why the flash assists in die filling for hot forging.
(b) Explain why forged parts demonstrate better fatigue properties than parts made by sand casting process.
(c) Explain how hot and cold forged components would differ from each other.

Question 4

With respect to the processing of brittle materials.

(a) Grinding is typically used for processing brittle materials. Explain how material is removed via grinding.
(b) If you wanted to obtain a mirror-like finish on a planar glass workpiece, outline a process chain that would enable you to achieve that. In your answer comment on potential sources of subsurface damage and how it can be mitigated/removed.
(c) Suggest a non-traditional process that could also be used to remove material from a brittle material. In your answer describe its material removal mechanism and any material constraints for the process.

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Question 5

Consider a connecting rod (connects the piston head to the crank shaft) that may be in an internal combustion engine – See Figure 3 for details. The following questions will ask you to compare and contrast additive manufacturing (AM), casting, and forging. Assume a comparable alloy and post-manufacture heat treatment is used for each process. Assume that the AM process used is laser powder bed fusion (LPBF).

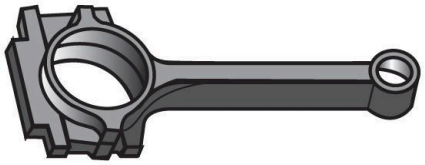

Figure 3: A connection rod (including the bottom bearing cap). The overall dimensions are approximately 150 mm in length, 50 mm in width, and 25 mm in depth.

(a) Briefly describe the LPBF process. Be sure to include details regarding the feedstock, the energy source, and the layerwise process. Where possible, describe dimensional scale in approximate terms, e.g., feedstock size, energy source point of interaction with the feedstock, layer thickness, build size, etc.
(b) Compare the material properties, microstructure, and defects typical of AM to these other processes.
(c) Compare the implications of AM on the part geometry/design to these other processes.
(d) Compare the implications of AM on manufacturing economics to these other processes.

Question 6

Heat treatment of iron-carbon alloys is heavily utilized to alter workpiece properties. Considering an iron-carbon alloy, provide details on the following;

(a) **(7 pts)** What is the net effect of quenching and the expected resulting microstructure?
(b) **(7 pts)** What does a tempering heat treatment entail, and how does it affect the material properties?
(c) **(6 pts)** Explain the limitations of an iron-carbon phase diagram (or indeed any metal alloy phase diagram).