

NATIONAL UNIVERSITY OF IRELAND  
GALWAY

SUMMER EXAMINATIONS 1999

**Second University Examination in  
Industrial Engineering and Information Systems**

Production Engineering

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Instructions: Time allowed: three hours  
Attempt all questions from section A  
Attempt three questions from section B  
See further instructions at beginning of section A

## Section A

Instructions: Attempt all questions  
Correct answers: 2 marks  
Use Answer Sheet at back of examination paper for your answers  
There are a total of 20 correct answers

- (i) Grain boundaries are examples of which one of the following defects:  
(a) dislocation (b) Frenkel defect (c) line defect (d) surface defect
2. The shear strength of a metal is usually greater than the tensile strength  
(a) true (b) false
3. Which of the following materials has the highest specific heat  
(a) aluminium (b) concrete (c) polyethylene (d) water
4. The predominant phase in an iron-carbon alloy with 99% Fe at room temperature is:  
(a) austenite (b) cementite (c) delta (d) ferrite (e) gamma
5. In precipitation hardening, the hardening of the metal occurs in which of the following steps:  
(a) aging (b) quenching (c) solution treatment
6. Which of the following comes closest to expressing the chemical composition of clay ?  
(a)  $\text{Al}_2(\text{Si}_2\text{O}_5)(\text{OH})_4$  (b)  $3\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$  (c)  $\text{SiO}_2$
7. Degree of polymerisation is which one of the following:  
(a) proportion of the monomer that has been polymerized  
(b) sum of the molecule weights of the mers in the molecule  
(c) average number of mers in the molecule chain
8. Wood is which one of the following composite types  
(a) CMC (b) MMC (c) PMC
9. Total solidification time in casting is defined as which one of the following:  
(a) time between pouring and cooling to room temperature  
(b) time between pouring and solidification  
(c) time between solidification and cooling to room temperature
10. Which one of the following casting metals is most important commercially  
(a) bronze (b) cast iron (c) cast steel (d) zinc

11. Which of the following terms refers to the glassy state of a material:  
(a) crystalline    (b) polycrystalline    (c) vitreous    (d) devitrified
12. In cold isostatic pressing (powder metallurgy) the mould is typically:  
(a) rubber    (c) sheet metal    (c) toolsteel    (d) textile
13. Average flow stress is stress multiplied by which of the following  
(a)  $n$     (b)  $(1+n)$     (c)  $1/(1+n)$      $n$  = strain hardening exponent
14. Flash in impression die forging serves no useful purpose  
(a) true    (b) false
15. Holding force in drawing is likely to be which of the following relative to maximum drawing force:  
(a) equal to    (b) less than    (c) greater than
16. Which of the following will improve surface finish in grinding:  
(a) higher wheel speed    (b) larger infeed    (c) lower work speed
17. For which of the following values of chip thickness  $t_o$  in metal cutting would you expect specific energy to be lowest  
(a) 0.010mm    (b) 0.025mm    (c) 0.120mm
18. Which of the following is a main function of cutting fluid in machining:  
(a) improve surface finish    (b) remove heat from the process  
(c) wash away chips    (d) reduce forces and power
19. Which of the following processes uses mechanical energy as the principal energy source:  
(a) laser beam machining    (b) ultrasonic machining    (c) wire EDM
20. Which of the following arc welding processes use non-consumable electrodes  
(a) SMAW    (b) GMAW    (c) FCAW    (d) GTAW

## Section B

1. (a) Define the terms
- (i) phase
  - (ii) solid solution
  - (iii) intermediate phase
- (6)

(b) The melting point of two metals A and B are 1083°C and 1453°C respectively. The table below shows the temperatures at which solidification begins and ends, when various alloys of the two metals are cooled from liquid to the solid state.

Amount of B in alloy (%)	0	10	20	30	40	50	60	70	80	90	100
Temperature at beginning of solidification (°C)	1083	1160	1220	1270	1320	1350	1380	1400	1430	1440	1453
Temperature at end of solidification (°C)	1083	1080	1090	1110	1140	1170	1220	1270	1330	1380	1453

- (i) Using graph paper, draw the thermal equilibrium diagram according to the given data and label all lines and regions in the diagram. (4)

- (ii) Determine from the diagram composition of the phases present at 1260°C for the 50/50 alloy. (6)

- (c) What is the amount of each phase using the inverse lever rule (4)

2. (a) Explain how Cast Iron is produced. In particular outline how different cooling rates effect the type of cast iron produced. (6)

(b) Explain the differences between the following cast irons in terms of their properties and carbon content. Use sketches of grain structure to illustrate your answers:

- (i) Grey Cast Iron
  - (ii) White Cast Iron
  - (iii) Ductile Iron
- (6)

- (c) What are the principle differences between cast iron and steel ? (2)

- (d) Give an example of three products produced using either grey, malleable, or nodular cast irons. (6)

3. (a) Explain, using sketches, the principle of operation of the punching process. In your explanation make particular reference to the fundamental mathematical relationships involved for calculating shearing pressure. (8)

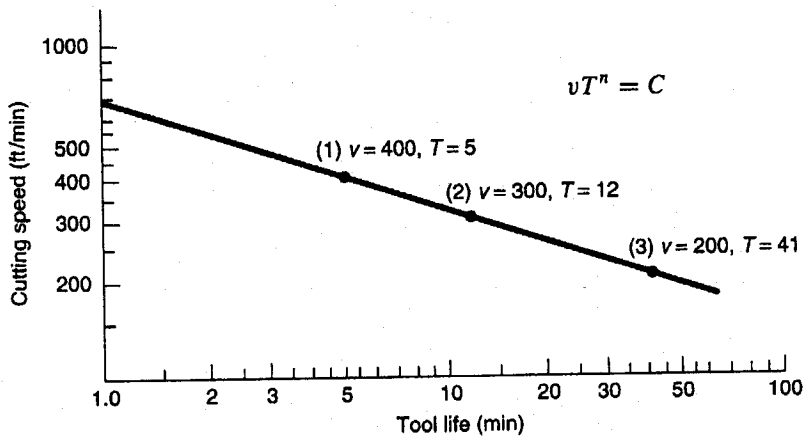
(b) A hole 100mm in diameter is to be punched in a steel plate 5.6mm thick. The material is cold-rolled 0.4% carbon steel for which the ultimate shear stress is 550N/mm<sup>2</sup>. With normal clearance of 10% on the tools, cutting is complete at 40% penetration of the punch. Give suitable diameters for the punch and die and a suitable shear angle in order to bring the work within the capacity of a 300kN press. (12)

4. (a) Derive expressions for the power and energy relationships used in the single point metal cutting process. (10)

(b) A turning operation is carried out on aluminium (100BN). The cutting conditions are  $v=1.3\text{m/s}$ ,  $f=0.75\text{mm/rev}$  and  $d=4\text{mm}$ . The lathe has a mechanical efficiency of 0.8. Determine (a) the cutting power and (b) the gross power in the turning operation in watts (Specific energy for aluminium,  $U = 0.7\text{N-m/mm}^3$ ) (10)

5. Answer two of the following

- (a) The curve below illustrates a natural log plot of cutting speed versus tool life for a single point cutting tool. Using the generic form for the Taylor tool life equation also illustrated, determine the values of  $n$  and  $C$  for this cutting tool.



(10)

- (b) What are the advantages and disadvantages of welding compared to other forms of joining processes. What is meant by the term fraying surface. Define the term fusion weld. What is the difference between a fusion weld and solid state weld.

- (c) A cylindrical part is warm upset forged in an open die.  $D_o=50\text{mm}$  and  $h_o=40\text{mm}$ . Final height is 20mm. Coefficient of friction at the die work interface is 0.20. The work material has a flow curve defined by  $K=600\text{Mpa}$  and  $n=12$ . Determine the force in the operation when the final height is reached. (10)