UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACHELOR OF ENGINEERING TECHNOLOGY IN PHYSICAL METALLURGY
SUBJECT	:	MECHANICAL METALLURGY 2B
CODE	:	MMEMTB2
DATE	:	SUPPLEMENTARY EXAMINATION JANUARY 2020
DURATION	:	3 HOURS
WEIGHT	:	40:60
TOTAL MARKS	:	85

ASSESSOR	:	MR E. GONYA
MODERATOR	:	MR JM PROZZI
NUMBER OF PAGES	:	4 PAGES

INSTRUCTIONS	:	ANSWER ALL QUESTIONS
REQUIREMENTS	:	CALCULATOR

QUESTION 1 (35 MARKS)

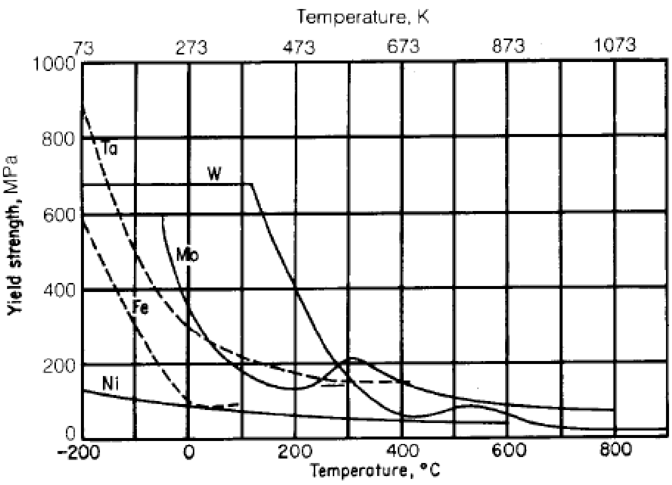
1.1 How would you control the DBTT of ferritic steel for use at low temperature application? Give your answer in the context of microstructure and chemical composition. (6)

1.2 Using dislocation theories, explain why FCC material like Cu absorb high impact energies even at low temperatures. (4)

1.3 Low carbon content reduces DBTT, however it may bring some advantage and disadvantage. Explain using suitable diagram both advantage and disadvantage of lowering carbon content when controlling for DBTT. (5)

1.4 Discuss the physical significance of plastic instability in the context of forming of metals. (5)

1.5 Given the following diagram:



Explain why the yield strength of Nickel is slighly affected across all temperatures than those of Fe, Mo and Ta. (5)

1.6 Under which conditions will the movement of the screw dislocation be restricted in the single plane. (4)

1.7 Differentiate between strain hardening and geometric hardening. (6)

QUESTION 2 (50 marks)

2.1. Prove that under plain strain state of stress ($\sigma_1,\ \sigma_2\ \neq 0\ and\ \sigma_3 = \frac{\sigma_1+\sigma_2}{2}$), the von Mises and Tresca criterion are equivalent. (10)

2.2 If the yield strength of the material is 180 MPa, determine whether yielding will occur according to von Mises criterion given the following stress state:

$$\begin{bmatrix} 400 & 0 & 100 \\ 0 & 300 & 100 \\ 100 & 100 & 200 \end{bmatrix} \text{MPa}$$ (10)

2.3 The critical resolved shear stress for yielding in aluminium is 240 KPa, assuming any possible FCC slip system, calculate the tensile stress required to cause yielding when the tensile axis is [001]. (5)

2.4 A tensile stress is applied along [123] direction in a copper single crystal. If the slip system is given as ($\bar{1}$11) [101], determine mathematically whether the single crystal will undergo geometrically hardening or softening. (10)

2.5 The true strain rate during tension test is given by: $\dot{\varepsilon} = \frac{\frac{dL}{L}}{dt}$, If the initial cross sectional of the rod specimen is A_0 at t = 0 and $\dot{\varepsilon}$ is constant

2.5.1 Prove that at t = t_i the mathematical expression for instantaneous cross sectional area is given by: $A_i = A_0 \exp(-\dot{\varepsilon}t)$. (10)

2.5.2 Calculate the instantaneous cross sectional area after 60s, given that the true strain rate is 0.001 s^{-1} and specimen diameter is 12mm. (5)

Total = 85

$\sigma^3 - I_1\sigma^2 + I_2\sigma - I_3 = 0$	$\sigma_x + \sigma_y + \sigma_z = I_1$ $\sigma_x\sigma_y + \sigma_y\sigma_z + \sigma_x\sigma_z - \tau_{xy}^2 - \tau_{xz}^2 - \tau_{yz}^2 = I_2$ $\sigma_x\sigma_y\sigma_z + 2\tau_{xy}\tau_{yz}\tau_{xz} - \sigma_x\tau_{yz}^2 - \sigma_y\tau_{xz}^2 - \sigma_z\tau_{xy}^2 = I_3$
$\sigma_1 = \frac{E}{1-\nu^2}(\varepsilon_1 + \nu\varepsilon_2)$ $\sigma_2 = \frac{E}{1-\nu^2}(\varepsilon_2 + \nu\varepsilon_1)$	$\sigma_Y = \tau_{CRSS}\left(\frac{1}{\cos\phi\cos\lambda}\right)$
$\sigma_1^2 + \sigma_2^2 - \sigma_1\sigma_2 = \sigma_o^2$	
$\sigma_0 = \frac{1}{\sqrt{2}}\left[(\sigma_1-\sigma_2)^2 + (\sigma_2-\sigma_3)^2 + (\sigma_3-\sigma_1)^2\right]^{1/2}$	
$\cos\theta = \frac{h_1h_2 + k_1k_2 + l_1l_2}{(h_1^2+k_1^2+l_1^2)^{1/2}(h_2^2+k_2^2+l_2^2)^{1/2}}$	
$\dot{\varepsilon} = \frac{v}{L_i}$, $\dot{e} = \frac{v}{L_o}$, $\dot{\varepsilon} = \frac{\dot{e}}{e+1}$	