MACHAKOS UNIVERSITY

University Examination 2018/2019

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF BUILDING AND CIVIL ENGINEERING

FIRST YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR IN CIVIL ENGINEERING

ECV 101 MATERIAL SCIENCE

DATE: 30/7/2019 **TIME: 2.00-4.00 PM**

INSTRUCTIONS: Answer questions **ONE** and any other **TWO** questions.

QUESTION ONE

a) With appropriate illustrations explain the difference between the following pairs of terms as used in Material Science: (6 Marks)

   i. Metals and polymers

   ii. Elastic range and plastic range

   iii. Physical property and mechanical property

   iv. True stress and proof stress

b) Discuss the factors that should be considered by a civil engineer when selecting engineering materials (6 Marks)

c) Discuss any four reasons for mechanical testing of materials (6 Marks)

d) A steel rod of varying cross-section is loaded as shown in Figure Q1(d). sketch and label the longitudinal stress diagram, indicating where the maximum stress occurs (6 Marks)

e) Sketch the typical creep curves for various stresses at constant temperature and discuss the four principal aspects of each of the curve (6 Marks)

QUESTION TWO

The data in Table Q2 were obtained from a tensile test carried out on a mild steel specimen 25 mm diameter according to the BS 18: Part 2, 1971.

Table Q2

Load (kN)	16	32	64	96	128	136	144	152	158
Extension (mm)	0.020	0.040	0.080	0.120	0.160	0.171	0.184	0.216	0.756
Load (kN)	154	168	208	222	226	216	192	185.4	
Extension (mm)	1.476	3.025	9.060	15.0	21.0	27.5	30.0	Failure	

Plot the load-extension diagram, label it appropriately and determine:

a) The Young's modulus

b) Proportional limit stress

c) Yield point stress

d) Tensile strength

e) Percentage elongation (20 Marks)

QUESTION THREE

a) Discuss the influence of the following group of factors that influence fatigue property of engineering materials:

   i. Environmental factors

   ii. Geometrical factors (8 Marks)

b) A series of crack growth tests on a moulding grade of plastic gave the results in Table Q3(b):

$\frac{da}{dN}$ (m/cycle) x 10^{-7}	2.25	4.0	6.2	11	17	29
ΔK (MN $m^{-3/2}$	0.42	0.53	0.63	0.79	0.94	1.17

If the material has critical stress intensity factor of 1.8 MN m-3/2 and is known that the moulding process produces a defect 40 μm long, estimate the maximum repeated tensile stress which could be applied to this material for at least 10^6 cycles without causing fatigue failure (12 Marks)

QUESTION 4

The data in Table Q4 shows the creep data obtained for a metal using a stress of 100 MN/m2 at a range of temperatures. If the constant "a" in the Larsen-Miller parameter is 20, calculate the time to failure at a stress of 100 MN/m2 when the temperature of the material is 700^{o}C (R = 8.314 J mol^{-1} K) (20 Marks)

Table Q4

Temperature (^{o}C)	100	200	250	300
ε_0 (mm/mm/hr)	2.1 x 10^{-23}	2.77 x 10^{-17}	4.25 x 10^{-15}	2.7 x 10^{-13}
Temperature (^{o}C)	400	500	600	
ε_0 (mm/mm/hr)	1.72 x 10^{-10}	2.06 x 10^{-8}	8.25 x 10^{-7}	

QUESTION 5

a) i When a load is gradually applied to a bar and the bar undergoes a change in length, the load moves as the bar deforms and therefore work is done by the load on the bar. Show, from first principles, that for a gradually applied tensile load the work done in straining the bar is a function of modulus of resilience (5 Marks)

ii A steel rod of length 1 m is of diameter 75 mm over a portion 0.7 m long abd of diameter 45 mm over the remainder. Calculate the strain energy in the rod, when it is subjected to an axial tension of 50 kN. Young's modulus is 210 kN/mm^2 (5 Marks)

b) i In Figure Q5, the mass m falls through height h onto the collar at the lower end of the bar, causing a maximum extension in the bar of ΔL. Show, from first principles, that the static force P that will cause same extension when gradually applied is given as:

$$P = mg\left[1+\sqrt{\left(1+\frac{2hAE}{mgL}\right)}\right] \quad (5\ Marks)$$

ii A vertical bar of length 2.5 m and diameter 20 mm is held rigidly at the upper end and is fitted with a collar at the lower end onto which a weight W may fall freely

from a height of 350 mm above the collar. Calculate the maximum value allowable for W if the stress in the bar must not exceed 120 N/mm^2.

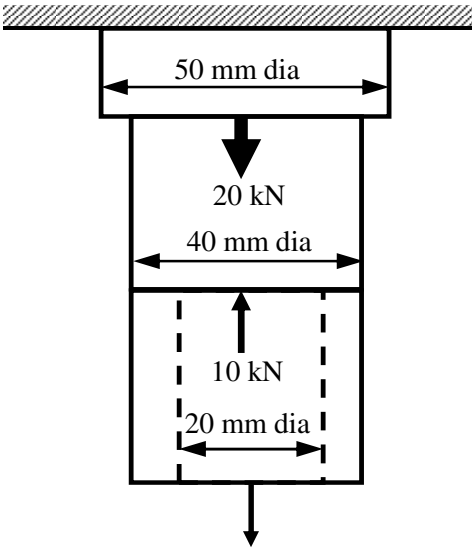

Figure Q1(d)

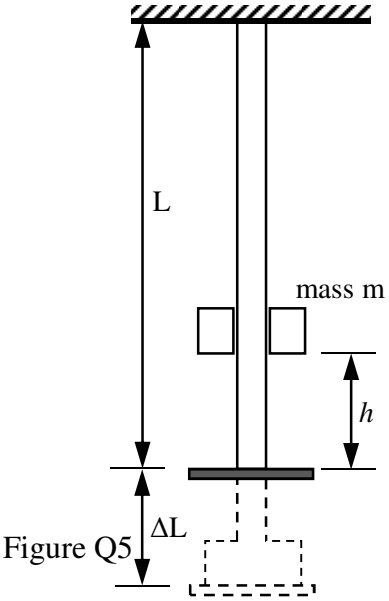

Figure Q5