MACHAKOS UNIVERSITY

University Examinations for 2020/2021 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF BUILDING AND CIVIL ENGINEERING

FIRST YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (CIVIL ENGINEERING)

ECV 101: MATERIAL SCIENCE

DATE: 26/2/2021 **TIME: 2.00-4.00 PM**

INSTRUCTIONS

- *This paper comprises of five questions. Answer **three** questions*
- *Question one is **compulsory** and carry 30 marks*
- *Use well labeled and neat diagrams where applicable.*
- *Answer any other **two** questions*

QUESTION ONE (30 MARKS) (COMPLSORY)

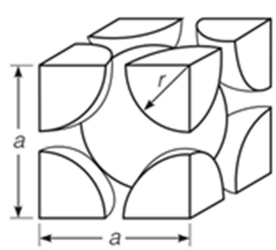
a) Materials are generally classified into three categories based on the predominant types of bond. What are these three categories and what are the predominant types of bond in each category? For each category, provide two examples of common materials used by civil engineers (6 marks)

b) What are the five classes of ceramic materials? (5 marks)

c) What are the 4 types of organic solids used in engineering applications? Define each one and give examples. (4 marks)

d) Describe FCC, BCC, and HCP lattice structures. (3 marks)

e) Referring to the BCC lattice structure shown in the figure below (3 marks)



i. Determine the number of equivalent whole atoms in the unit cell.

ii. Calculate the relation between a and r.

iii. Calculate the atomic packing factor of the BCC lattice structure.

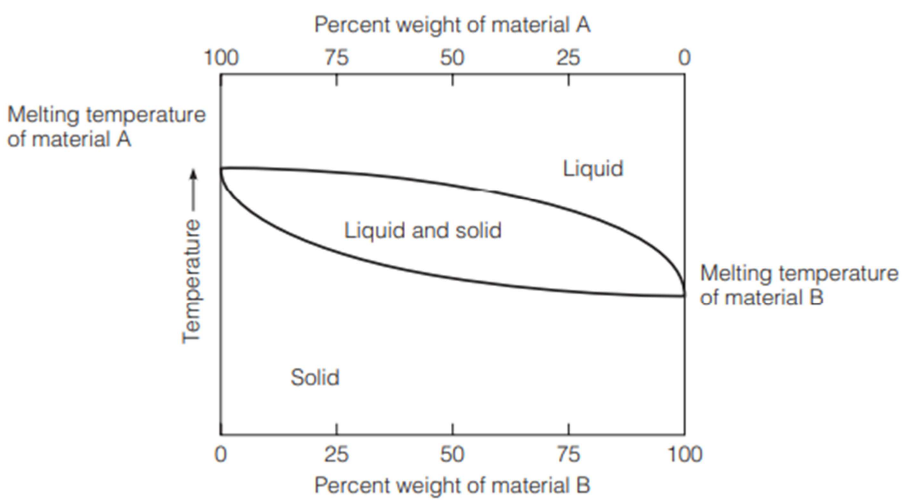
f) On a graph, show the stress–strain relationship under loading and unloading for the following two materials:

(4 marks)

i. nonlinear elastic material

ii. elastoplastic material with strain hardening

g) Considering an alloy of the two soluble components A and B described by a phase diagram below, determine the masses of the alloy that are in the liquid and solid phases at a given temperature if the total mass of the alloy is 100 grams, component B represents 40% of the alloy, 20% of the liquid is component B, and 50% of solid is component B. (5 marks)



QUESTION TWO (20 MARKS)

a) What are the differences between "modulus of resilience" and "toughness"? Explain graphically. (4 marks)

b) An asphalt concrete cylindrical specimen with a 4-inch diameter and a 6-inch height is subjected to an axial compressive static load of 150 lb for 1 hour, after which the load is removed. The test was performed at a temperature of 100°F. The height of the specimen was measured at different time intervals during loading and unloading for a total of 2 hours and produced the following results: (16 marks)

Time, minutes	Specimen Height, inches	Time, minutes	Specimen Height, inches
0	6.0000	60.01	5.9772
0.01	5.9916	62	5.9807
2	5.9870	65	5.9841
5	5.9833	70	5.9879
10	5.9796	80	5.9926
20	5.9753	90	5.9942
30	5.9725	100	5.9954
40	5.9708	110	5.9959
50	5.9696	120	5.9964
60	5.9688		

i. Using a graph paper, plot the stress versus time and the strain versus time on two separate graphs.

ii. How much is the elastic strain?

iii. What is the permanent strain at the end of the experiment?

iv. What is the phenomenon of the change of specimen height during static loading called? What is the phenomenon of the change of specimen height during unloading called?

QUESTION THREE (20 MARKS)

a) Briefly discuss the three mechanisms by which coatings provide corrosion protection for steal. (6 marks)

b) A high-yield-strength alloy steel bar with a rectangular cross section that has a width of 37.5 mm, a thickness of 6.25 mm, and a gauge length of 203 mm was tested in tension to rupture. The load and deformation data were as shown in table below; (14 marks)

Load (kN)	Displacement (mm)	Load (kN)	Displacement (mm)
0	0	159.4	8.560
18.5	0.102	161.2	9.856
84.3	0.379	162.8	11.217
147.4	0.623	164.2	12.588
147.6	1.744	165.0	13.789
149.2	4.327	165.8	15.201
150.8	4.742	166.6	18.767
153.9	6.030	153.6	30.746
157.0	7.339		

Using a spreadsheet program, obtain the following:

i. A plot of the stress–strain relationship. Label the axes and show units.

ii. A plot of the linear portion of the stress–strain relationship. Determine modulus of elasticity using the best-fit approach.

iii. Proportional limit.

iv. Yield stress.

v. Ultimate strength.

vi. If the specimen is loaded to 155 kN only and then unloaded, what is the permanent deformation?

vii. In designing a typical structure made of this material, would you expect the stress applied in (f) safe? Why?

QUESTION FOUR (20 MARKS)

a) Discuss five important factors to consider when selecting engineering materials. (10 marks)

b) Name the five primary factors that make aluminum an attractive structural engineering material. (5 marks)

c) A pine wood specimen was prepared with actual dimensions of 50mm ×50mm ×250mm and grain parallel to its length. The deformation was measured over a gauge length of 200 mm. The specimen was subjected to compression parallel to the grain to failure. The load–deformation results are as shown in the table below. (10 marks)

Load (Kn)	Deformation (mm)
0	0
8.9	0.457
17.8	0.597
26.7	0.724
35.6	0.838
44.5	0.965
53.4	1.118
62.3	1.270
71.2	1.422
80.1	1.588
89.0	1.765
97.9	1.956
106.8	2.159
111.3	2.311

i. Using a graph paper, plot the stress–strain relationship.

ii. Calculate the modulus of elasticity.

iii. What is the failure stress?

QUESTION FIVE (20 MARKS)

a) The following laboratory tests are performed on steel specimens: (6 marks)

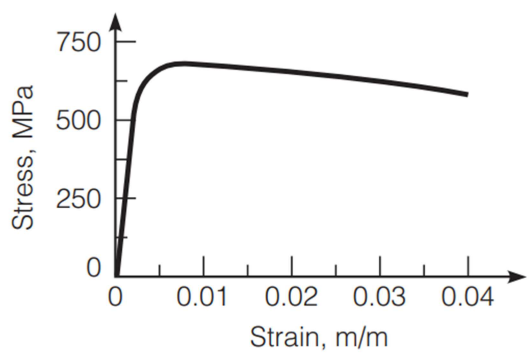
i. Tension test

ii. Charpy V notch test

iii. Bend test

What are the significance and use of these tests?

b) Testing a round steel alloy bar with a diameter of 15 mm and a gauge length of 250 mm produced the stress–strain relation shown in figure below. (14 marks)



Determine

i. The elastic modulus

ii. The proportional limit

iii. The yield strength at a strain offset of 0.002

iv. The tensile strength

v. The magnitude of the load required to produce an increase in length of 0.38 mm

vi. The final deformation, if the specimen is unloaded after being strained by

vii. The amount specified in (e) in designing a typical structure made of this material, would you expect the stress applied in (e) reasonable? Why?