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KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2020/2021 ACADEMIC YEAR

FOURTH YEAR SECOND SEMESTER
SPECIAL/SUPP EXAMINATIONS

FOR THE DEGREE OF B.SC (PHYSICS)

COURSE CODE: SPH 424

COURSE TITLE: THE COMPOSITES

DURATION: 2HRS

DATE: 21/1/2022 **TIME:** 8.00am-10am

INSTRUCTIONS TO CANDIDATES

- Answer question ONE (compulsory) and any TWO of the remaining questions.
- Attempted questions must be indicated on front cover of answer booklet.
- Every question should be started on new page and question indicated respectively.

Question One (30mks)

a. What are composite materials and state the reason why composites are preferred over pure materials. (3mks)

b. Discuss any two main divisions of composite materials citing the distinguishing features of each. (4mks)

c. State the major reason for the creation of ceramic matrix composites. (2mks)

d. Calculate the elastic modulus of the Glass Fiber-Reinforced Composite-Transverse Direction composite assuming that the stress is applied perpendicular to the direction of fiber alignment. (4mks)

e. What are the differences in strengthening mechanisms for large particle and dispersion-strengthened particle reinforced composites? (4mks)

f. Cite one desirable characteristic and one less desirable characteristic for each of
   a. Discontinuous-oriented fiber-reinforced composites. (2mks)
   b. Discontinuous-randomly oriented fiber-reinforced composites. (2mks)

g. Name and briefly discuss two sub-classification of structural composites. (4mks)

h. For a fiber-reinforced composite, the efficiency of reinforcement is dependent on fiber length l according to $\eta = \frac{l-2x}{l}$, where x represents the length of the fiber at each end that does not contribute to the load transfer. Make a plot of η versus l to $l = 50$ mm (2.0 in.) assuming that $x = 1.25$ mm (0.05 in.). (5mks)

Question Two (20mks)

a. A continuous and aligned glass fiber-reinforced composite consists of 40 vol% of glass fibers having a modulus of elasticity of 69 GPa (10×10^6 psi) and 60 vol% of a polyester resin that, when hardened, displays a modulus of 3.4 GPa (0.5×10^6 psi).
   (a) Compute the modulus of elasticity of this composite in the longitudinal direction. (4mks)
   (b) If the cross-sectional area is 250 mm^2 (0.4 $in.^2$) and a stress of 50 MPa (7250 psi) is applied in this longitudinal direction, compute the magnitude of the load carried by each of the fiber and matrix phases. (4mks)
   (c) Determine the strain that is sustained by each phase when the stress in part (b) is applied. (4mks)

b. In the table below are listed four hypothetical aligned fiber-reinforced composites (labeled A through D), along with their characteristics.

Composite	Fiber type	Vol fraction Fibers	Fiber strength (MPa)	Aver fiber length (mm)	Critical length (mm)
A	Glass	0.2	3.5×10^3	8	0.70
B	Glass	0.35	3.5×10^3	12	0.75
C	Carbon	0.40	5.5×10^3	8	0.40
D	Carbon	0.30	5.5×10^3	8	0.50

On the basis of these data, rank the four composites from highest to lowest strength in the longitudinal direction, and then justify your ranking. (8mks)

Question Three (20 mks)

a. Carbon is a high-performance fiber material that is the most commonly used reinforcement in advanced polymer-matrix composites. Discuss any five reasons why Carbon Fiber-Reinforced Polymer (CFRP) Composites is commonly used. (10mks).

b. Show that for longitudinal loading, the ratio of the load carried by the fibers to that carried by the matrix is given by $\frac{F_f}{F_m} = \frac{E_f V_f}{E_m V_m}$ where the initials have their usual meaning. (10mks)

Question Four (20mks)

a. The mechanical properties of cobalt may be improved by incorporating fine particles of tungsten carbide. Given that the moduli of elasticity of these materials are, respectively, 200 GPa (psi) and 700 GPa psi), plot modulus of elasticity versus the volume percent of tungsten carbide in cobalt from 0 to 100 vol%, using both upper- and lower bound expressions. (8mks)

b. A continuous and aligned fibrous reinforced composite having a cross-sectional area of 970 mm^2 (1.5 $in.^2$) is subjected to an external tensile load. If the stresses sustained by the fiber and matrix phases are 215 MPa (31,300 psi) and 5.38 MPa (780 psi), respectively, the force sustained by the fiber phase is 76,800 N (17,265lb_f), and the total longitudinal composite strain is 1.56×10^{-3}. Determine

a) The force sustained by the matrix phase. (4mks)

(b) The modulus of elasticity of the composite material in the longitudinal direction. (4mks)

(c) The moduli of elasticity for fiber and matrix phases. (4mks)

Question Five (20mks)

a. Explain with suitable sketches the filament winding method of producing a polymer matrix composites. (8mks)

b. Derive an expression for the modulus of elasticity for a continuous and aligned fibrous composite loaded in the direction of alignment. (12mks)