On Polymer Composites

1. Glass particles for reinforcement are available in various forms. Rank the following in order of their expected efficiencies as reinforcing particles. (Hint: consider the area/volume as a measure of efficiency).
   (i). Glass flakes: diameter = 1 mm, thickness = 4 μm.
   (ii). Glass fibers: diameter = 12 μm, length = 3 mm.
   (iii). Glass fibers: diameter = 7 μm, length = 1 mm.
   (iv). Solid glass spheres: diameter 44 μm.
   (v). Hollow glass spheres: diameter 75 μm.

2. Show that the theoretical maximum volume fraction for identical continuous fibers with circular cross-section in a composite is 0.91. (Hint: Maximum volume fraction is achieved when fibers are hexagonally close-packed)

3. A composite panel consists of the following by weight: 20% glass fibers ($\rho = 2.55$ g/cm^3), 55% polyester resin ($\rho = 1.20$ g/cm^3), and 25% calcium carbonate ($\rho = 2.70$ g/cm^3). Calculate ϕ_f and ρ_c for this composite.

4. A carbon/epoxy composite filled with 30% by ***mass*** of continuous, uniaxial fibers, has the following component properties: σ_f=3200 MPa, E_f= 230 GPa, ν_f = 0.22, ρ_f = 1400 kg/m^3; σ_m = 60 MPa, E_m = 2.4 GPa, ν_m = 0.38, and ρ_m = 984 kg/m^3. A tensile stress of 100 MPa is **applied parallel** to the fibers. (a) Calculate the tensile strength of the composite (i) parallel to the fibers, and (ii) the elastic modulus parallel to fiber direction. (b) Predict the resulting strains (i) ε_1, parallel to the fiber direction, and (ii) ε_2, perpendicular to the fiber direction. (See Example 2 of Lecture 5a notes).