030312 Quiz 5 Polymer Processing

1) The striped texture was discussed in class since it is the simplest case for calculation of the correlation function.
   a) Give the correlation function and the assumptions associated with it for the striped texture.
   b) Give the correlation function if one of the two phases is much smaller than the other.
   c) Show how the scale of segregation (correlation length) is calculated from this correlation function.
   d) If the stripes are not straight is there a problem with using this correlation function? Explain.

2) a) Explain the difference between the intensity of mixing, I, and the mixing index, M.
   b) Give an example of situations where the mixing index, M, would be more appropriate to use.
   c) Give an example of a situation where the intensity of mixing, I, would be more appropriate to use.
   d) What statistical distribution is the mixing index based on?

3) a) Sketch the residence time distribution function and the cumulative residence time distribution function for a batch mixer with two chambers such as was discussed in.
   b) Sketch the residence time distribution function and the cumulative residence time distribution function for a continuous mixer similar to that discussed in class.
   c) Sketch the strain distribution function and the cumulative strain distribution function for a batch mixer with two chambers such as was discussed in class.
   d) Sketch the strain distribution function and the cumulative strain distribution function for a continuous mixer similar to that discussed in class.
   e) How would you calculate the mean strain and mean residence time from these functions?

ANSWERS: 030312 Quiz 5 Polymer Processing

1) a) R(r) = 1 - r/K where K = $(L_1L_2)/(L_1+L_2)$ the assumption is that only the lateral (normal to the stripes) correlations are considered. Also assume that the stripes are straight and of fixed dimensions. Implicit is a two-phase assumption.
b) R(r) = 1- r/L_1 where L_1 is the smallest phase.
c) The scale of segregation is calculated from the integral of the correlation function from 0 to K. The scale of segregation is K/2.
d) Yes, the function only considers correlation normal to the stripes. If the stripes are not straight then the function ignores correlations associated with waviness.

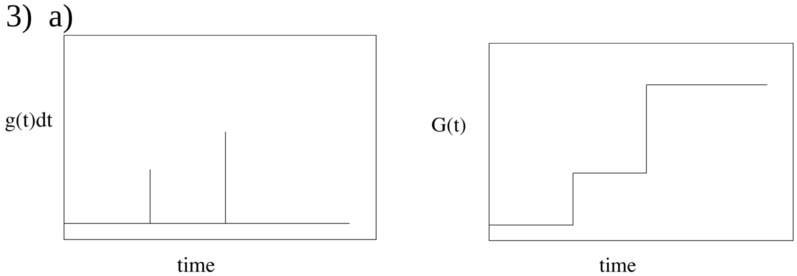
2) a) M measures the ratio of standard deviations of the particle size distribution assuming a fixed concentration difference between the two phases, $M = S^2/\sigma^2$ where for a binomial distribution, $\sigma^2 = np(1-p)$, where p is the probability that a lattice site is occupied by one of the two phases and n is the number of lattice sites in the system, and $S^2 = \dfrac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}$. The intensity of mixing, I, measures the concentration differences between phases so is a measure of the diffusion of the two components. The equation for I is given in the class notes, $I = S^2/\sigma^2 = (x_1 - x_2)^2$, where x_i is the composition of one of the two phases.

b) For mixing of carbon black (immiscible) in PE M is appropriate.

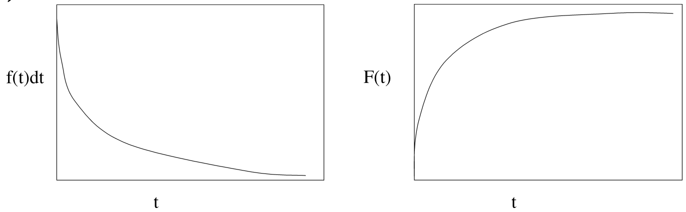
c) For mixing of organic pigment in a polypropylene color concentrate in polypropylene I would be a better measure of mixing since the phases are diluted by diffusion.

d) The binomial distribution is used as a the basis for both I and M.
$b(k:n,p) = \dfrac{n!}{k!(n-k)!}p^k(1-p)^{(n-k)}$ where the parameters are discussed in the class notes.

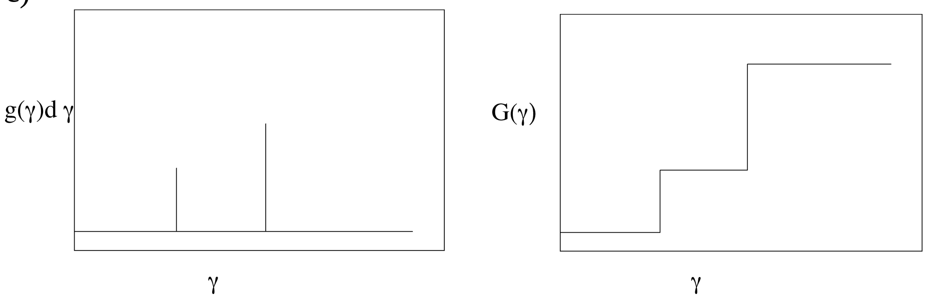
3) a)



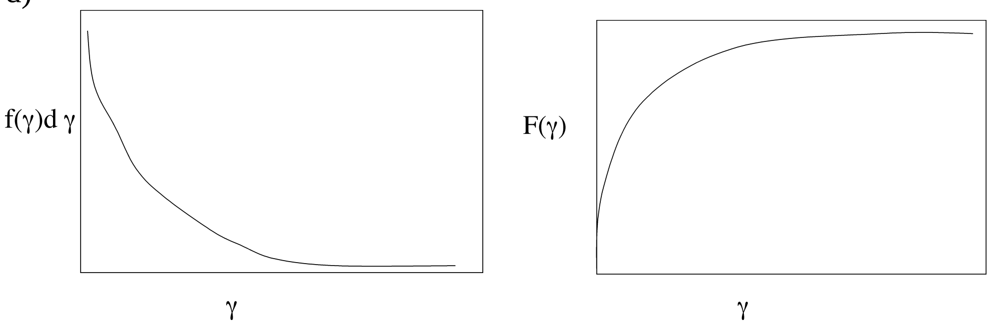
b)



c)



d)



e) Mean strain is calculated from the strain distribution function through an integral,

$$\bar{\gamma} = \int_0^{\gamma_{max}} \gamma g(\gamma) d\gamma$$

or

$$\bar{\gamma} = \int_0^{\gamma_{max}} \gamma f(\gamma) d\gamma$$

similar functions define the mean residence time.