1. (a) The active power(P) and reactive power(Q) flow between nodes a and b (from a to b) :

$$P = Re\{S\} = \frac{I}{2}(V_a cos(\theta_a - \phi_i) - V_b cos(\theta_b - \phi_i))$$

$$Q = Im\{S\} = \frac{I}{2}(V_a sin(\theta_a - \phi_i) - V_b sin(\theta_b - \phi_i))$$

   (b) The active power(P) and reactive power(Q) flow between nodes a and b (from b to a) :

$$P = Re\{S\} = \frac{I}{2}(V_a cos(\theta_a - \phi_i) - V_b cos(\theta_b - \phi_i))$$

$$Q = Im\{S\} = \frac{I}{2}(V_a sin(\theta_a - \phi_i) - V_b sin(\theta_b - \phi_i))$$

   (c) The condition under which the active power flow between a to b is positive :

$$V_a cos(\theta_a - \phi_i) - V_b cos(\theta_b - \phi_i) > 0$$

2. The time difference between the positive peaks of the two signals:

$$\Delta t = 5ms$$

3. The phasor representation of the time-shifted signal is $10\angle\pi/2$
4. The time reference must be shifted $1.67ms$ towards the left
5. The expressions for V_c and θ_c are:

$$V_c = \sqrt{(V_a cos\theta_a + V_b cos\theta_b)^2 + (V_a sin\theta_a + V_b sin\theta_b)^2} = \sqrt{V_a^2 + V_b^2 + 2V_a V_b cos(\theta_a - \theta_b)}$$

$$\theta_c = tan^{-1}(\frac{V_a sin\theta_a + V_b sin\theta_b}{V_a cos\theta_a + V_b cos\theta_b})$$