Chapter 5

5.1) $\sigma_p = [1-5\tau/(\sqrt{3}K_{sp})]/[3+\tau/(\sqrt{3}K_{sp})] < 0$

which implies that the tension τ should be in the range:

$$\frac{1-5\tau}{\sqrt{3}K_{sp}} \times \frac{\sqrt{3}K_{sp}}{3+\tau} < 0 \rightarrow \frac{1-5\tau}{3+\tau} < 0 \rightarrow \tau < -3 \text{ or } \tau > \frac{1}{5} \;/\; \tau \in (-\infty, 3) \cup (\tfrac{1}{5}, $$

b) The area per junction vertex for a six-fold network is $\frac{\sqrt{3}}{2} S_\tau^2$ where S is the spring length, which under tension τ obeys the relation:

$$S_\tau = S_0 / (1-\tau/(\sqrt{3}K_{sp}))$$

for unstressed networks the Area is equal to $\frac{\sqrt{3}}{2} S_0^2$, so the ratio of area per junction in stressed network to unstressed network is:

$$\frac{A_s}{A_0} = \frac{S_\tau^2}{S_0^2} = \frac{3K_{sp}^2}{(1-\tau)^2} \quad \text{for } \tau \in (-\infty, -3) \cup (\tfrac{1}{5}, \infty) \rightarrow 0 < \frac{A_s}{A_0} < \infty$$

c) The human red blood cell cytoskeleton is also a six fold structer, therefore the smallest τ needed for σ_p is $\tau = \frac{1}{5}$, a tensive force slightly larger than $\frac{1}{5}$ in magnitude.

at zero tension shear modulus of a six-fold network is $\mu = \frac{\sqrt{3}}{4} K_{sp}$ so $K_{sp} = 11.55 \times 10^{-6}$ J/m^2

5.2) The temperature is found from figure 5.18 to be around

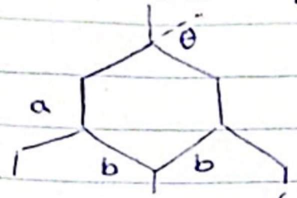
$\frac{K_B T}{K_{sp} S_0^2} \approx 0{,}2$, and for the red blood cell cytoskeleton we have:

$S_0 = 75 \times 10^{-9} m$

$\mu = 5 \times 10^{-6} J/m^2 \xrightarrow[\text{six-fold}]{\tau = 0} K_{sp} = \frac{4}{\sqrt{3}} \mu = 11.55 \times 10^{-6} \frac{J}{m^2}$

$\rightarrow \frac{K_B T}{K_{sp} S_0^2} \xrightarrow{T = 37} = 0{,}06$ operating temperature of RCC $\rightarrow \left(\frac{K_B T}{K_{sp} S_0^2}\right)_{\text{spectrin}} > \left(\frac{K_B T}{K_{sp} S_0^2}\right)_{\text{red cell}}$

5.7) $K_{bend} = \frac{\xi_p K_B T}{b}$ $\qquad b_{\alpha\text{-actin}} = 15 \times 10^{-9}\,m \qquad b_{fimbrin} = 15 \times 10^{-9}\,m$



$$Y = 4 K_{bend} \frac{a}{b^3} \qquad a_{\alpha\text{-actin}} = 40 \times 10^{-9}\,m \qquad a_{fimbrin} = 14 \times 10^{-9}\,m$$

$$15 \times 10^{-6} \times 1.38 \times 10^{-23} \times 300$$

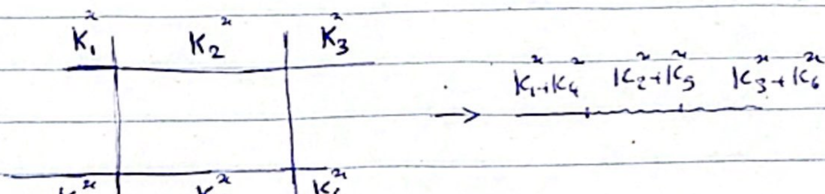
$$Y_{actin} = 4 \times \frac{\xi_p \times K_B T}{15 \times 10^{-9}} \times \frac{40 \times 10^{-9}}{(15 \times 10^{-9})^3} = 0.19\ J/m^2$$

$$Y_{fimbrin} = 4 \times \frac{\xi_p K_B T}{b} \times \frac{a_{fimbrin}}{b_{fim}^{\ 3}} = 0.07\ J/m^2$$

$$K_{bend\text{-}\alpha actin} = K_{bend\text{-}fimbrin} = 4.14 \times 10^{-18}\ J$$

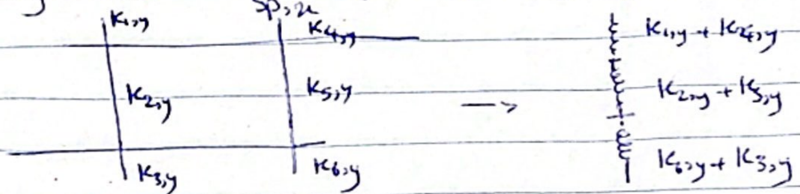
5.8) a) k_{sp}

in x direction:



effective spring constant $K_{sp,x}^{-1} = (K_1 + K_4)^{-1} + (K_2 + K_5)^{-1} + (K_3 + K_6)^{-1}$

in y direction:



effective spring constant $K_{sp,y}^{-1} = (K_{1,y} + K_{4,y})^{-1} + (K_{2,y} + K_{5,y})^{-1} + (K_{6,y} + K_{3,y})^{-1}$

where each spring segment with length L has spring constant $K_i = \pi R^2 Y / L_i$

b) $Y_x = K_{spring,x} \times \frac{L_x}{L_y} =$

$Y_y = K_{spring,y} \times \frac{L_y}{L_x}$

$L_y = 120\,nm$

$L_x = 240\,nm$