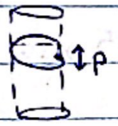
Chapter 4

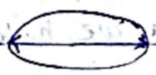
4.1) pitch(p) $= 5\times10^{-6}$ m $\qquad C = \dfrac{4\pi^2 r}{4\pi^2 r^2 + p^2} = 6{,}3\times10^{5}$

radius(r) $= 0{,}5\,\mu m$

b) $\alpha = \dfrac{\Phi}{L}$ 
twist angle

The ribbon has deformed $\Phi = 2\pi$ through length $L = p \rightarrow \alpha = \frac{2\pi}{5}\times10^{6}$

$\rightarrow$ The differmation of $\Phi = 2\pi$ has happened along a small length of order μm, So our twist angle is much more than $\frac{2\pi}{5}$, around 10^6 times that amount.

4.2)  $a = 9\times10^{-9}$ m

$b = 5\times10^{-9}$ m

a) K_{tor} (elipticed rod) $= \dfrac{\mu\pi a^3 b^3}{a^2+b^2} = \dfrac{10^{8}\pi\times9^3\times5^3}{9^2+5^2} = 2.70\times10^{-25}$ J.m

b) $p = 74$ nm $\quad a = 9$nm $\longrightarrow d_a = \sqrt{(2\pi a)^2 + p^2} = 93.13\times10^{-9}$ m

c) $p = 74$nm $\quad b = 5$nm $\longrightarrow d_b = \sqrt{(2\pi b)^2 + p^2} = 80.39\times10^{-9}$ m

4.3) $\tau = 10^{-20}$ N-m

$L = 10^{-5}$ m

a) $K_{tor} = \mu\pi\dfrac{R^4}{2} = 9.82\times10^{-26}$ J.m

$R = 5\times10^{-9}$ m

b) $\alpha = \dfrac{\tau}{K_{tor}} = \dfrac{10^{-20}}{9.82\times10^{-26}} = 101859\,\frac{1}{m} \approx 10^{5}\,\frac{1}{m}$

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4.4) $\langle \phi^2 \rangle^{1/2} = \left(\frac{K_B T L}{K_{tor}} \right)^{1/2}$

let's set $K_{tor\,F\text{-}actin} = 10^{-27}$ J.m , therefor $K_{tor\,microtuble} = 10^{-24}$ J.m

$$L = \frac{K_{tor} \times \langle \phi^2 \rangle}{K_B T} = \frac{10^{-24} \times 9 \times \left(\frac{5 \times \pi}{180}\right)^2}{1.38 \times 10^{-23} \times 300} = 1{,}65 \times 10^{-5} \text{ m}$$

The microtuble should have length equal to $1{,}65 \times 10^{-5}$ m or $16.5\ \mu m$.

4.5) $L = 14800$ base pairs $= 14800 \times 0{,}34 \times 10^{-9} = 5{,}032 \times 10^{-6}$ m
$\phi = 75 \times 2\pi$ (75 turns) $= 150\pi$

$\Big\} \; \alpha \approx 30\pi \times 10^{6}$

The drag torque experienced by the sphere is equal to the torque applied to the DNA to twist it 75 times. This torque is equal to:

$$\tau = K_{tor}\alpha \xrightarrow{\text{So}} K_{tor} = \frac{\tau}{\alpha} = \frac{14\pi R^3 \eta \omega}{30\pi \times 10^6} = 4.1 \times 10^{-28}$$